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WILSON'S CARPENTRY AND JOINERY.

FOURTH EDITION.

April, 1891.

MANCHESTER

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WILSON'S
CARPENTRY AND JOINERY.

BY

JOHN WILSON,

(Author of "Building Construction;" Lecturer on Building Construction, Carpentry and Joinery, &c., in the Manchester Technical School; First Class Honours and First Medal in Carpentry and Joinery, 1886).

FOURTH EDITION.

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PREFACE TO SECOND EDITION.

IN issuing the 10th thousand in so short a time from the issue of the first thousand, the author feels that he need not say anything in praise of his endeavours to assist those who are anxious to secure a sound technical, as well as practical, education in this important branch of labour.

He has spared no pains to make the letterpress and plates as explicit in substance, and neat in appearance as possible in a book published at so low a price—whilst the knowledge gained, not only from theory and long study, but also from many years' of practical labour in the subjects of which the book treats, enables him to recommend it with confidence to all who are endeavouring to become theoretically or practically proficient in the work.

At the examinations in Carpentry and Joinery held under the City and Guilds of London Institute for the whole of the United Kingdom, the class taught by the Author has taken the first place for the last three years in succession.

The Author regrets the little delay in the issue of this edition, but trusts that his friends will feel themselves compensated by its increased size and usefulness; twenty pages have been added. These will be found valuable additions.

The issue of the first book has brought the Author many letters from unseen friends in all parts of the world, expressing their thanks and kind wishes: he would take this opportunity of reciprocating their good wishes, and he trusts that his further endeavours in the interests of sound technical education, may be of still more service to those who have in the past been able to improve their positions, and to increase their knowledge of the subject.

He has endeavoured to make what appears to some a dull and dry subject—bright and interesting, and if this should prove to be the case in the future as it has in the past, the Author will feel amply recompensed for his efforts to increase the knowledge and usefulness of those, who, like himself, have the cause of technical education at heart.

URMSTON, NEAR MANCHESTER,
July, 1887.

PREFACE.

THE following book has been written to assist students who are studying for the examination of the City and Guilds of London Institute in Carpentry and Joinery, and for such as wish to acquire a knowledge of bevels, enlarging or diminishing moulds and developing surfaces, &c. The cuts or bevels, and the developing of surfaces are based upon true Geometrical principles. The reasoning is such that anyone with ordinary intelligence will be able to grasp the why and the wherefore, *e.g.*, why a line drawn from a certain point and joined to a known angle, forms with a certain line the bevel sought.

The method of obtaining bevels is somewhat new, but the Author's long experience of applying this system convinces him that it only requires to be known to be appreciated.

The scale ($\frac{1}{12}$) at the foot of each plate will be found serviceable, as it will take the place of a two-foot rule or ordinary scale.

The chapters on staircasing and handrailing are written by my able and valued colleague, Mr. J. MATTINSON, teacher of staircasing and handrailing in the Technical School, whose practical knowledge well qualifies him to be an authority on the subject.

The arrangement of texts and plates opposite each other is an advantage, the worth of which cannot be over-estimated, both in the point of time and in the feeling of pleasure and satisfaction which ensues, when the reader finds that he can realise the description of the object at a glance, without having his attention distracted by the necessity of continually referring to plates in another part of the book. No stronger evidence of its value could be adduced than the number of complimentary letters in its favour sent to the Author by Professors of Colleges, Science Teachers, and others, who have used his elementary book on building where the same arrangement prevails.

A few examples are given at the end of each chapter, so that the student may test his knowledge as he proceeds.

JOHN WILSON.

BUILDING DEPARTMENT,

TECHNICAL SCHOOL, MANCHESTER, *June*, 1886.

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SCALES, &c.

Fig. 1. Shows how to divide a given space into any number of equal parts. The line given is 3″ long, and requires to be divided into five equal parts The usual method is as shewn. Draw any inclined line from one end and indefinite in length ; on this line set off the number of equal spaces you require with the compasses, 1, 2, 3, 4, 5, and from 5, on this inclined line draw back to the opposite end of the line from where you began ; then from points 4, 3, 2, 1, draw lines parallel to the first, and where these cut the original line they divide it into the necessary number of equal parts. When divided in this manner it is often difficult to say where the two lines meet, as the angle is so sharp or acute.

Fig. 2. Shows a better method, which will be seen at a glance. It is as follows : At one end of the line to be divided, erect a perpendicular, then take an ordinary rule or scale and placing it on the opposite end of the line as shewn, turn it until the necessary number cuts the vertical line ; then at the points (which in this case are 1, 2, 3, 4, 5) drop perpendicolars, and these are parallel to the vertical line, and divide it equally into five parts, and being at right angles to the first determine the exact points. If the given space had been to divide into 10, then points each ½″ would have been taken ; if into 40, then every ⅛″ and so on. This method is used throughout the book for dividing joists, spars, studs, &c.

Fig. 3. Shows an ordinary scale when 1″=1′, *i.e.*, the scale is one-twelfth or 1″=12″. In ordinary drawing for Building Construction (with the exception of some very few details which are full size), the parts have to be reduced, and this process is known as drawing to scale, each part being reduced in exact proportion.

Fig. 4. Shows a plain scale of feet and inches ; when 1″ represents 9″ the scale is ¾.

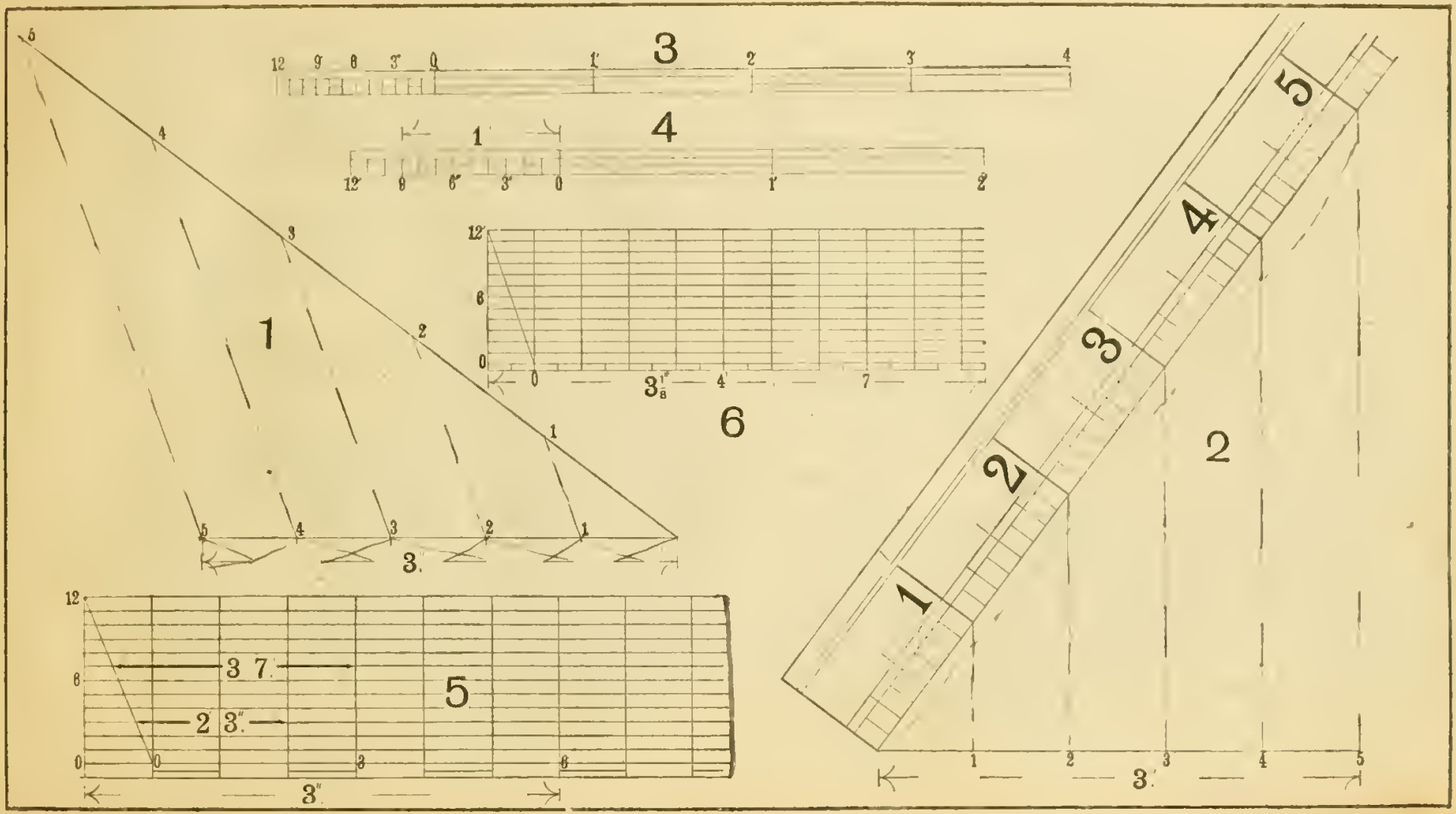
Fig. 5. Represents a scale $\frac{1}{24}$, *i.e.*, 1″=2′ 4″. In order to draw a scale of this class, first rid the fraction of inches ; to do this, multiply by three, then a line 3″ long will represent 7′. Divide this line into seven parts (by any of the methods just explained), then each space represents 1′. Next divide the left-hand space into twelve parts, this can be managed best by making twelve equal spaces as shown and drawing the diagonal line. Two spaces are figured, one showing 3′ 7″, and the other 2′ 3″.

If $\frac{1}{48}$ scale is asked for, then for every 1″ on your drawing, the piece of work would be 48″ or 4′. A scale of $\frac{1}{60}$ is 5′ to 1″, &c. ; ⅜, ⅝, ⅞, are used for representing complicated pieces of mechanism, as in watches, &c. In these they are enlarged to show clearly what is wanted, and are read as follows :

First, if a space measures ⅜″ say, then the finished part would be ¼″.
Second, „ „ ⅝″ „ „ required size „ ⅜″
Third, „ „ 1″ „ „ „ „ ⅝″.

and so on, for any similar spaces. The three last scales will not be further noticed in this book.

Fig. 6. A drawing has no scale attached to it, but a space measuring 3½″ is figured 10′ 6″. Make a scale for the drawing. First mark off a line 3½″ as shown, and divide the line into 21 equal parts (see drawing), each space will represent 6″. Feet and inches may be shown. The latter by the diagonal method.


1
2
3
4
5
6
3.
3.
3 7.
2 3.
3.
3.

LEADWORK.

Lead gutters are required to carry off the water from roofs, &c.; in general they are box or V gutters. When gutters are more than 12′ long they require a break. These breaks are called drips, and are about 2″ deep and right across the width of the gutter.

Fig. 1. Shows an ordinary method. The bearers are about 12″ apart, 3″ × 2″, these are covered by ¾″ or 1″ boards; if a large surface has to be covered, the boards should be grooved and tongued to keep the edges level. In Fig. 1 A it is shown where the first piece of lead is turned up against the drip and into a rebate 1″ × ⅛″ at the top, rounded at the edge. The bottom piece being dressed to its place, the top piece laps over and down to within ¾″ from the bottom. The rebate in the top is often omitted. (See B)

Fig. 2. Shows how the lead is dressed over the rolls; they are 2½″ × 2″, and made egg-shaped. This shape is preferable to the semi-circular shape often used. These are used on lead flats, at the centre of long gutters, &c.

Fig. 3. Shows a section through a box gutter, with drips, falls, and cesspool; the gutter being supported by the iron columns which carry the principals. When the gutter is shallow, the lead may be in one width and turned over the eaves-pole, the usual cap flashings being dispensed with.

The cesspool is formed over the head of a column; this latter serves for a down spout.

The length of a cesspool should not be less than 18″, the full width of gutter, and from 3″ to 12″ deep.

Fig. 4. Shows the construction for a gutter behind a wall, when a parapet or higher wall rises above the eaves. A small corbel is brought out to receive a plate, 3″ × 2″, for the foot of the rafters. An offset of 4½″ serves the same purpose. The width of the gutter should be 9″, in order that a man may be able to walk in it. Small bearers, marked a, rest with one end on the rafter; the other end next the wall being carried by an upright, marked b. The board or gutter bottom is fixed to these bearers, and the lead dressed into it as shown; the piece of lead let into the wall is called a cap flashing.

Fig. 5. Shows a V gutter; this gutter and the box gutter are formed when two roofs meet in an inside. Fig. 5 is for a very small gutter of this class; the bearers for the gutter bottom are cut to the proper bevel and nailed on the spars.

Fig. 6. Explains a similar one to the last, but larger, 7″ boards being laid on either side, and known as layer boards. The bearers for the gutter bottom are nailed against the sides of the spar; this is not so good a plan as the last, owing to the fact that three-fourths of the bearers depend on the nails alone for their support.

Fig. 7. Shows how ridge rolls are covered, and the lead fixed by the S shaped piece of lead every 4′ to 6′, all nailing being dispensed with on the outside.

Fig. 8. Shows the construction for a secret gutter, when a roof abuts against a high wall, and it is desired to keep step and other flashings out of sight.

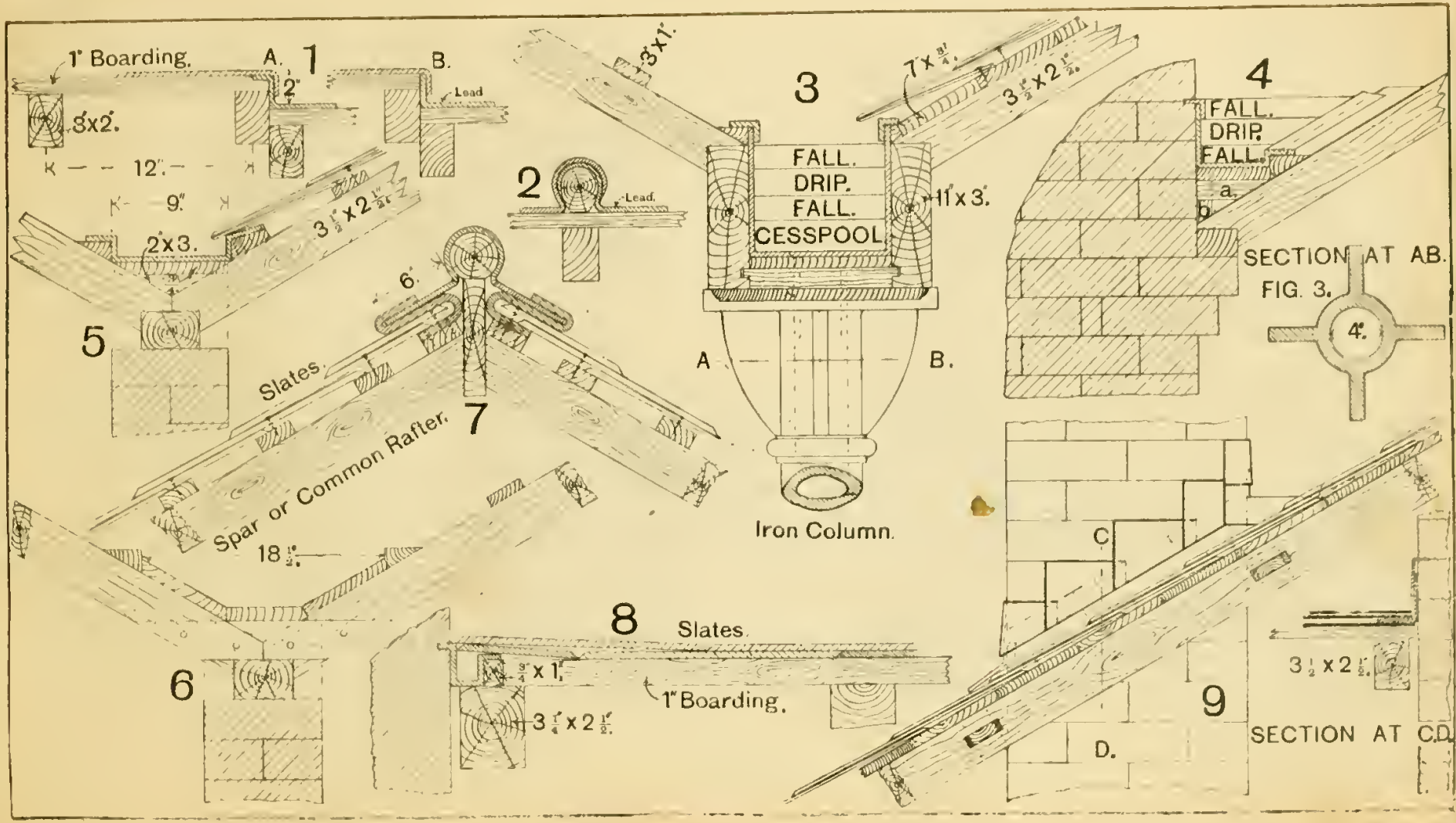
The spar next the wall has a ¾″ rib the full length of the spar, and the same depth as the slate battens; this forms one side of the gutter; the other side is formed by the wall; then the slates run over this and against the wall.

The above is for stone; when for a brick building, the gutter bottom must be level with the underside of the spar.

Fig. 9. Shows what is known as step-flashing for chimneys, &c.; the underflashings are 6″ broad, and 2½″ longer than the gauge of the slates; these are formed into an L, 3″ going up against the brickwork and 3″ on the slate; the last slate covers this lead over. The step or cap flashings are put in after the slater has finished. They are let ¾″ into the wall, and run up against the underflashing; the next laps ¾″ over the first; this is repeated until the whole is finished; the horizontal joints being filled with cement after the lead has been wedged in.

The above figure and the enlarged details, section at A B, will explain the process of step-flashing. Hip rolls are covered the same as ridge rolls. Valleys are similar to V gutters, but they require no drips, and the pieces at the side for tilting are only ¼″ deep, otherwise they twist the slates.

Owing to lead contracting and expanding so much, it should be left loose on one side at least.


1" Boarding.
A.
1
B.
2"
Lead
3"x2".
12".
9".
2"x3.
3 1/2" x 2 1/2".
2
Lead.
3"x1".
3
7" x 3/4".
3 1/2" x 2 1/2".
FALL.
DRIP.
FALL.
CESSPOOL
11" x 3".
A
B.
Iron Column.
4
FALL.
DRIP.
FALL.
a.
b.
SECTION AT AB.
FIG. 3.
4".
5
6".
Slates.
7
Spar or Common Rafter.
18 1/2".
6
8
Slates.
3/4" x 1".
1" Boarding.
3 1/4" x 2 1/2".
C
D.
9
3 1/2 x 2 1/2".
SECTION AT C.D.

LEADWORK.—*Continued.*

Fig. 1. Shows the plan of a lead gutter, and a cross and longitudinal section through the same. This gutter is for behind a parapet wall, has one drip, and the cesspool close to one end; this is marked C P in both plan and section. Only a few slates are shown in plan, in order to leave space for the section. This, with Fig. 4 on last page, will enable a student to follow all the details for a gutter of this class. The drip is formed, as shown in section, by trimming a piece of board from spar to spar, and then the small pieces shown in cross-section support the gutter bottom.

Fig. 2. Shows a plan of one corner of a hipped roof, and an enlarged section through the hip, showing how a secret gutter is formed on the hip when the slates are mitred. A and A are ¾″ slips and the depth of slate battens, and the full length of the hip to form the sides for the lead gutter. B and B are short strips nailed in between the spars and against the hip. These are to prevent the ends of the slate battens or boards from sagging where the end does not finish on a spar. The letters in plan and section are the same in order that the construction may be easily followed. The spars are shown in plan and the battens in section.

The above construction forms a secure and neat finish, as no hip tiles or lead rolls are required.

Fig. 3. This is a section through a chimney, showing how the rafters are trimmed and the small gutter at the back prepared in order to keep out the wet. The apron at the front is turned out upon the slates for a distance of 6″. The lead at the back is sometimes in one piece, but is often as shown; in fact, if the gutter be wide, then a cap flashing is indispensable.

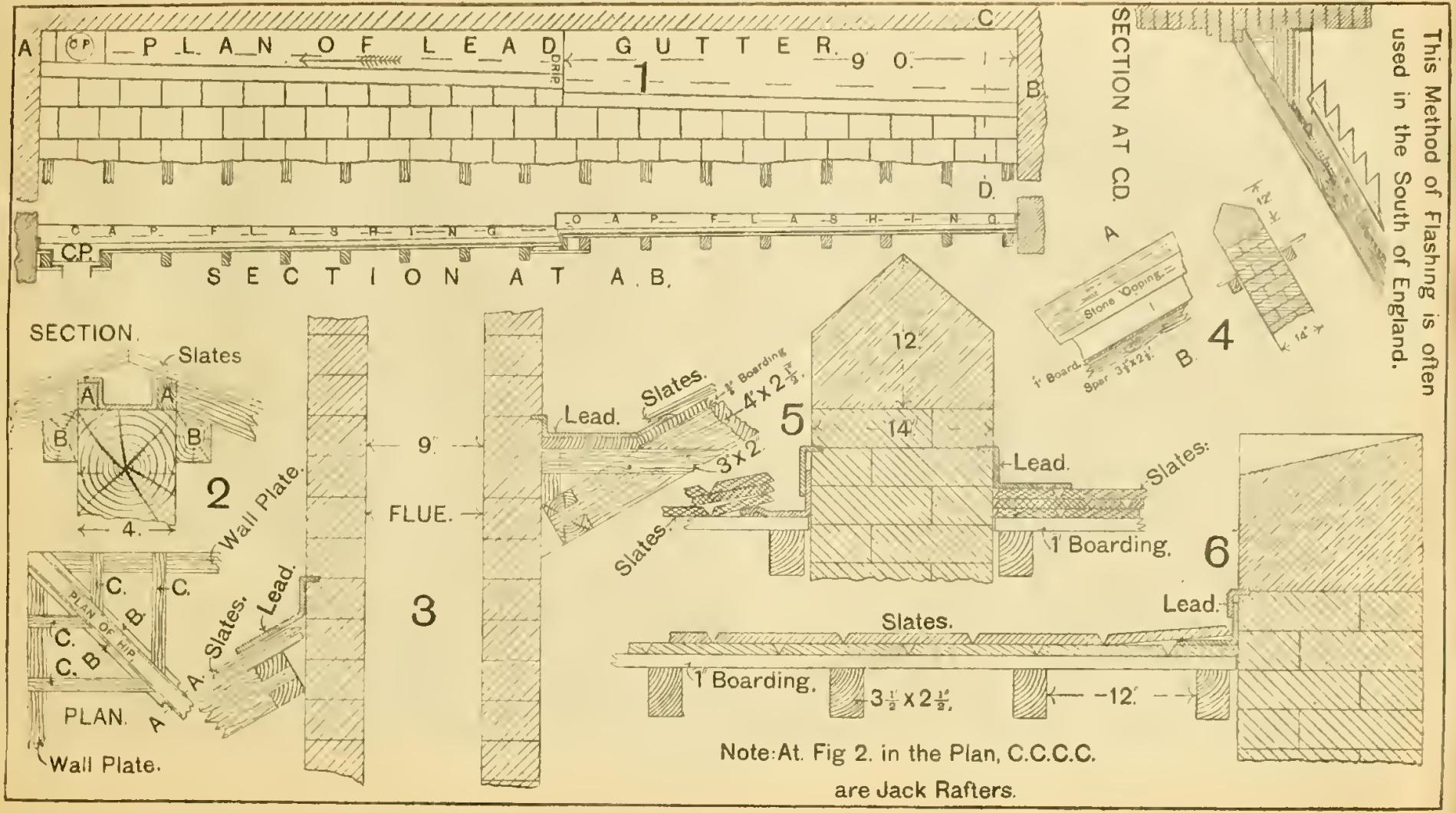
This should be worked along with Fig. 9 on the last page.

Fig. 4. Shows a stone coping to a party wall. These rise above the roof in fire-proof buildings. A side elevation of coping, spar, &c., is shown, and a section through A B to the same scale is given.

Fig. 5. This is an enlarged section through a similar wall to Fig. 4, taken at A B.

Two methods are shown; that on the left shows the slates kept off the wall and a small gutter at the side, a thin rib being fixed to turn the lead over, and at the same time cant the slates and throw the water from the wall. On the other side the lead is turned out on the slates about 6″. In this the section is taken through a lap, hence three thicknesses of slates are shown, and these are exaggerated to show the bevelled edges.

Fig. 6. Shows a section through a gable wall with a stone coping. This latter is bevelled to throw the water on the roof (see part not sectioned). In this the section is not at the lap. The lead is turned under the slates for at least 4″, and then the cap flashing inserted when the slating is finished. Any of these methods of keeping out the water may be used, as they are all practicable. Of the three the second is the cheapest, but the last is best. The details are to a large scale, and will be understood by examining the drawing.



This Method of Flashing is often used in the South of England.

FLOORS.

The floor is the horizontal assemblage of materials that divides one room from another, or the basement from the first rooms.

Fig. 1. Shows the plan of a common single floor, that is, the joists run from wall to wall, and support the ceiling as well as carry the floorboards. In floors of all descriptions what is known as trimming has to be done round such as fireplaces, trap-doors, well-holes for stairs, &c.

In this a fireplace is shown, and the trimming executed in the usual way. The two strong joists that run one on each side of the fireplace are the trimming joists, and the strong one that is trimmed into them is the trimmer. These are $7'' \times 4''$, and the common or bridging joists are $7'' \times 3''$.

On looking at the plan it will be seen that three common joists are tenoned into the trimmer, the number depending on the width of the chimney breast. This accounts for the trimming joists having to be stronger than the common joists, it being usual to add $\frac{1}{8}$ of an inch for every joist that has to be borne by the trimmer. The distance of this last from the jamb is about 15″.

Around the hearth a strip about $2\frac{1}{2}''$ of hard wood is put and mitred at the angles; see the piece on the trimmer. A naked floor is represented except at one corner where a few battens are shown with broken joints. In order to make the floor more rigid, a row of herring-bone bridging is put in near the middle. No wall-plates are shown, the joists rest on the bricks.

Fig. 2. Shows an enlarged section and plan of one side with trimmer, trimming joist, &c. In section the trimmer joist is shown 15″ from the jamb and the space filled in with a $4\frac{1}{2}''$ brick arch.

The abutments or skewbacks for this arch are formed as follows, a piece is cut out of the chimney breast, and on the opposite side against the joist, a bevelled piece of wood is nailed on.

The top of the brick arch is kept below the floor level; when the hearth flag is $2\frac{1}{2}''$ the arch is 3″ below, and this allows for a bed of mortar.

The hearth flag is often in two pieces, the piece between the jambs being thinner than the front piece; the former is known as the back hearth.

Fig. 3. Shows an enlarged section through three joists next the wall; in one bay, herring-bone bridging is given; in the other bay, pugging is shown. The pieces forming the struts are $2'' \times 1\frac{1}{2}''$, cut as shown, and nailed to the joists at the top and bottom edges. Allow $\frac{1}{4}''$ from each edge to keep clear of both floor and ceiling.

To draw the struts, mark these points on the top and bottom edge $\frac{1}{4}''$ from each; then from one of these as centre, and a radius equal to the depth of a strut, describe an arc of a circle, as shown, then a line from the other point and tangent to the arc gives the pitch of strut. A $\frac{1}{2}''$ bolt may be added if extra rigidity is required. Joists may also be bridged by pieces the depth of joists and $1\frac{1}{4}''$ or $1\frac{1}{2}''$ thick, cut in between the joists and laced with hoop iron.

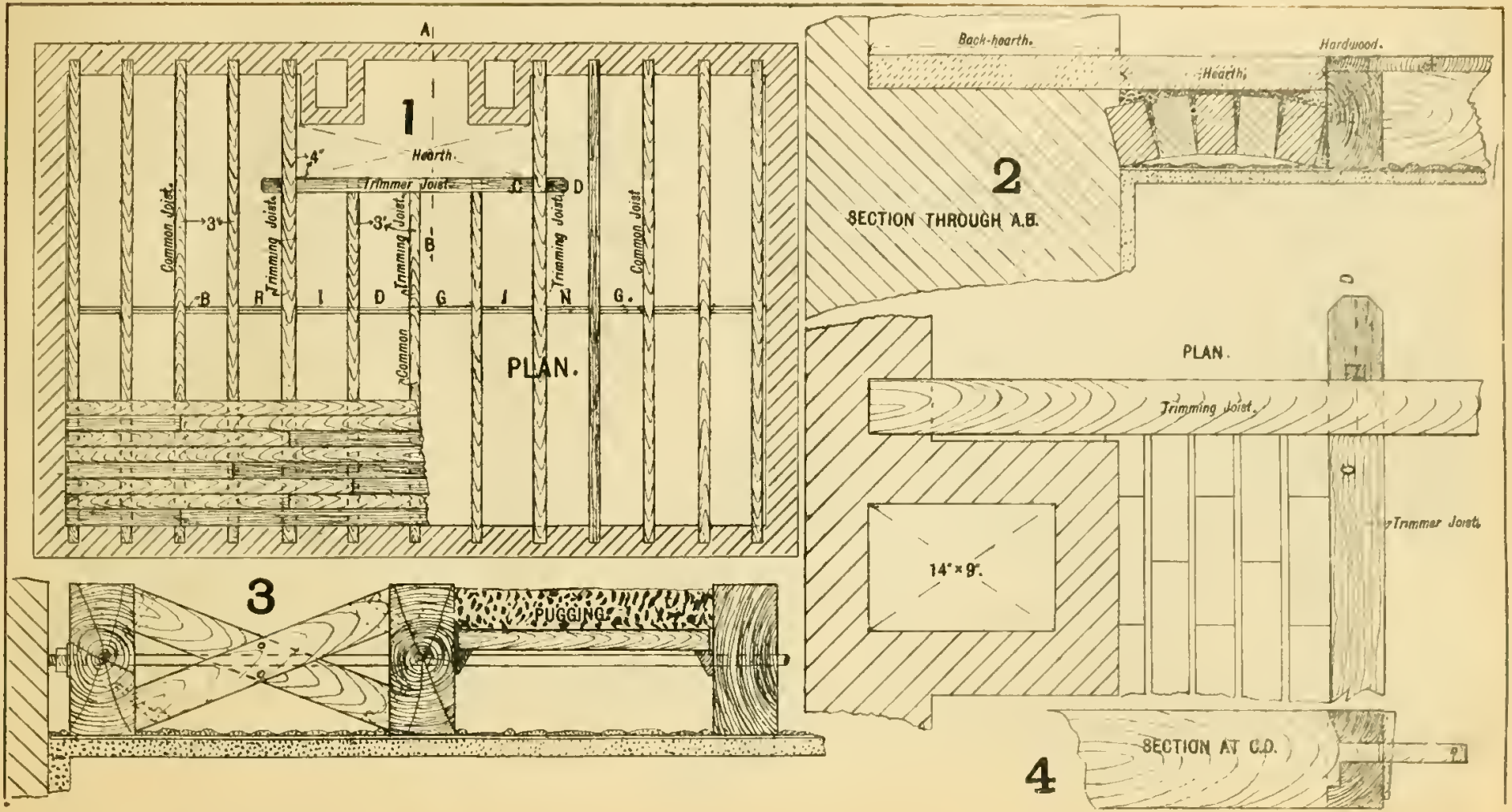
The pugging is provided for as follows: Small triangular pieces are nailed against the joists at the middle of their depth, and the full length from wall to wall; on these are put rough boards or slabs, care being taken to keep the joints $\frac{1}{4}''$ open. Then the pugging is spread on these 2″ to 3″ deep, it must not touch the floor boards; it is made of coarse mortar, ashes, sawdust, &c.

Fig. 4. Is an enlarged detail, showing the tusk joint between the trimmer and trimming joist; the ordinary tenon $\frac{1}{3}$ the thickness not being applicable. The thickness of tenon is $\frac{1}{6}$ the depth of joist, its bottom edge being in the centre of the joist, the necessary strength being obtained by sinking a piece below the tenon for a bearing, and at the top by sloping a piece off, as shown.

The sinking may be $\frac{1}{5}$ of the thickness of the joist, and its depth at least $\frac{3}{5}$ the full depth of the joist from the top edge. The reason is this: any ordinary joist may be reduced $\frac{1}{3}$ its depth at the ends and then it will break in the centre before the ends, and, by putting a thin tenon in the neutral axis, and the sinking below, the necessary $\frac{2}{3}$ of bearing is obtained; the trimming joist is not unnecessarily weakened by the tenon and bearing.

The two are held together by a wedge, care being taken to have a little extra out of the mortice, as shown, so that the two may be held close together. The tenon should project 6″ through.

Of the three floors to be shown in this book, the single floor is the strongest and cheapest, but privacy and a good ceiling are against this, as the sound is transmitted direct through the joists. The first of these is remedied as far as possible by pugging; and the vibration by the herring-bone struts and bolt, as they distribute the weight and preserve the ceiling.


A
1
Hearth.
4"
Trimmer Joist.
C
D
Common Joist.
3"
Trimming Joist.
3"
Trimming Joist.
B
Trimming Joist.
Common Joist
B
R
I
D
G
J
N
G.
Common
PLAN.
Back-hearth.
Hearth.
Hardwood.
2
SECTION THROUGH A.B.
PLAN.
Trimming Joist.
D
Trimmer Joist.
14" × 9".
3
PUGGING.
SECTION AT C.D.
4

FLOORS—*continued.*

Fig. 1. Is the plan of what is known as a double floor. These are used for larger spans than the last, or where a good ceiling, &c., is required.

They consist of three sizes of timber, viz., binders, bridging or common joists, and ceiling joists. The binders are the largest, and are put in position first; these are built in as the walls are taken up. In this they are taken 10″×8″, and 16′ bearing. The common joists are 7″×2½″, and the ceiling joists 3″×2″. In the plan, the joists are shown by single lines, 12″ centre to centre.

Fig. 2. Is the plan of a framed floor, and consists of girders, binders, bridging joists, and ceiling joists. The girders in the plan are 15″×9″, and have a 20′ bearing and 9″ wall-hold at each end on stone-pads 3′×9″×6″. Binders are 9″×6″ with 6″ wall-hold, on stone-pads 2′ 6″ long.

Fig. 3. Is an enlarged section through a binder at A B, Fig. I.

In preparing a floor of this class, care must be taken that the underside is not cut for the ceiling joists, or the fibre of the wood in any way tampered with. The ceiling joists are notched to fit on the binder, then the nails that hold these up are the only piercings made in the edge which is in tension. The common joists may be notched out half their depth, and let into the binder 1″ on each side; this is called a cogged joint. If the joist fits the sinking made, no injury is done to the binder, as the top side is in compression. The floor boards are treated in the same way as for a single floor.

Fig. 4. Shows a section through C D, Fig. 2. The tusk tenon is the same shape as the one for the single floor. If any extra arrangement is necessary to secure the girder and binder together, a bolt ought to be put in the middle of the binder; being in the neutral axis it is not injurious to the floor.

The worst arrangement for a floor of this class is to put one binder in, and that right in the centre, then the weight is brought to the weakest point. Cast-iron shoes or wrought-iron stirrups for the end of the binders may be used, as they do away with cutting holes facing each other on opposite sides in the girder; at the same time they concentrate the weight to one point, and not as seen in plan, where the binders are arranged to distribute the weight as much as possible.

The walls under the girders, for ten or twelve courses, ought to be built in good cement mortar. The last floor is a very expensive one; in addition to the timber and the labour spent on it, an extra depth of wall has to be taken up all round the building, which is a serious item.

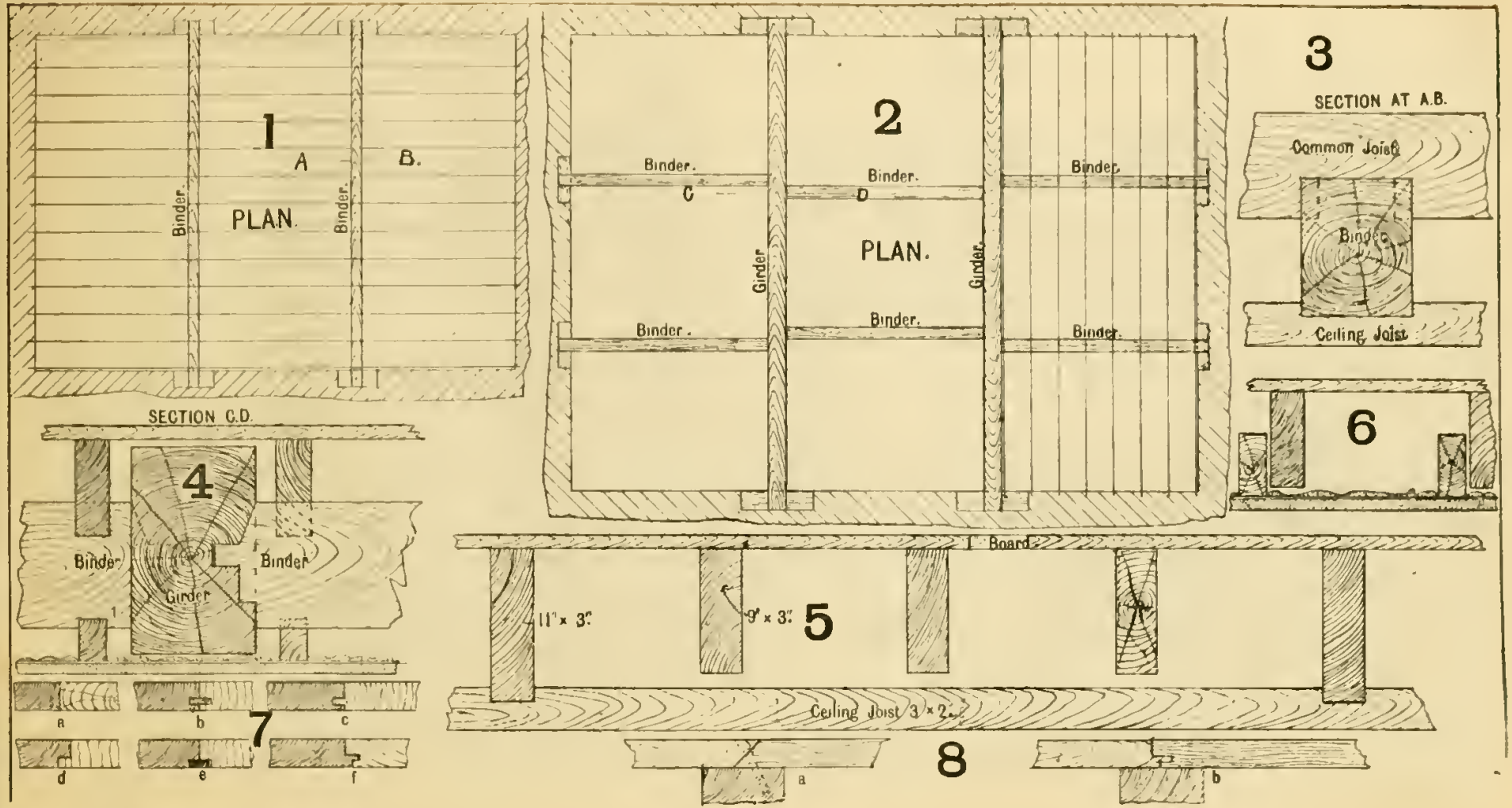
Fig. 5. Shows a partial double floor, three or four common joists and then a deeper one, to which the ceiling joists are fixed. In fixing the ceiling joists, care must be taken to keep them clear of the intermediate joists.

Fig. 6. A section through a floor is shown, where the bridging and ceiling joists are in no way connected together. Sound is prevented and a good ceiling secured by 1″ extra in depth over the common joists.

Fig. 7. These are some of the common methods of joining floor boards. a shows a square joint used in common floors. b shows what is known as ploughed and tongued, having a groove run in the edge of each board and a loose tongue put in the groove. These grooves in floor coverings are always nearer the bottom side, because all the wearing is on the top side. c is a grooved and tongued joint. d shows a rebated joint. e shows a rebated and filleted joint; and f shows a grooved and tongued joint where it is desirable to have a secret nailed floor.

Fig. 8. Two heading joints are shown. The one at a is bevelled and only shows two nails at each joint; b shows a heading joint used in a floor that has to have secret nailing. The board with the tongue on is fixed, and then the other is driven on. In a common square heading joint, four nails are used; this looks very unsightly.

Battens are 7″, and deals 9″ broad.


1
A
B.
PLAN.
Binder.
Binder.
2
Binder.
Binder.
Binder.
C
D
PLAN.
Girder.
Girder.
Binder.
Binder.
Binder.
3
SECTION AT A.B.
Common Joist.
Binder.
Ceiling Joist.
6
SECTION C.D.
4
Binder.
Binder.
Girder.
Board.
11" × 3"
9" × 3"
5
Ceiling Joist 3" × 2"
7
a
b
c
d
e
f
8
a
b

PARTITIONS.

Partition is the name given to the assemblage of materials that divides one room from another. In the four examples shown, they are known as self-supporting trussed partitions, *i.e.*, the framework is arranged so as to transmit the whole of the weight direct to the walls.

Fig. 1. Shows an ordinary 4″ partition, generally about 16′ long and 11′ high. The sill, door head, door posts, and braces are 4″ × 4″. The head or top sill 4″ × 3″. Studs 4″ × 2″, nogging pieces 4″ × 1½″, and the bolts ¾″ round iron. The doorway in the centre is for an ordinary door, 6′ 9″ × 2′ 9″. The sill at the bottom runs the full length across from wall to wall. When this is so, it must always go between two joists, as seen at X in enlarged section at the right hand corner; the reason for this is quite apparent– no impediment can be tolerated to interrupt the continuation of the floor.

When partitions have to cross the joists, the sill must be dispensed with in the doorway, and another form of joint introduced to secure the sill and door-post together.

The piece at the top from wall to wall is the head or top sill, and generally runs into the wall at the ends; this should only be tight at the sides, and plenty of room at the bottom or underside for settling, if necessary. The two strong pieces 3′ apart are door-posts; the short one 7′ high, is the door head. The narrow vertical pieces are the studs, and are about 12″ centre to centre. The horizontal pieces that run from brace to wall, on each side of the doorway, are the nogging pieces, and are nailed in between the studs to make them more rigid. The two inclined pieces from the end of the sill to the top of the door are braces.

A stone corbel has been thrown out for the sill to rest on at one end, and a brick corbel at the other. Sometimes one of these is used and sometimes the other, and in odd cases the sill is built in the wall.

Fig 2. The post and sill on the right hand side of the doorway are prepared for a partition that has to cross the joists and the post finishing on a joist. This is bevelled and secured by a bolt, &c, as shown. The braces are trimmed at the bottom end into the sill, and at the top into the door-posts. The foot, in addition to the abutment formed by cutting away a portion of the sill and a small stump tenon, has a ¾″ bolt to secure the two together.

At the top of these, two methods of forming the necessary abutments are shown. The door head is fixed by a small stump tenon; the ordinary studs have a stump tenon into the sill, and are nailed against the braces; and at the top in section, there is shown a rib nailed along the underside of the top rail, ⅓ the width and 1″ deep; the studs are forked out to fit on this and nailed, then the small tenon is omitted, as it applies to either top or bottom. The rib is well nailed opposite where each stud has to be fixed

Fig. 3. Shows how the post and sill may be secured together, when the post comes between two joists. The sill is housed into the post, this and the ordinary tenon being sufficient to form a good connection between the two.

Fig. 4. Shows a similar partition, but in this case it has to assist in carrying a floor on its head, extra strength being obtained by the bolts.

Fig. 5. Shows how the framework is arranged when a doorway at each side has to be provided for; the centre piece in the upper portion is called a puncheon.

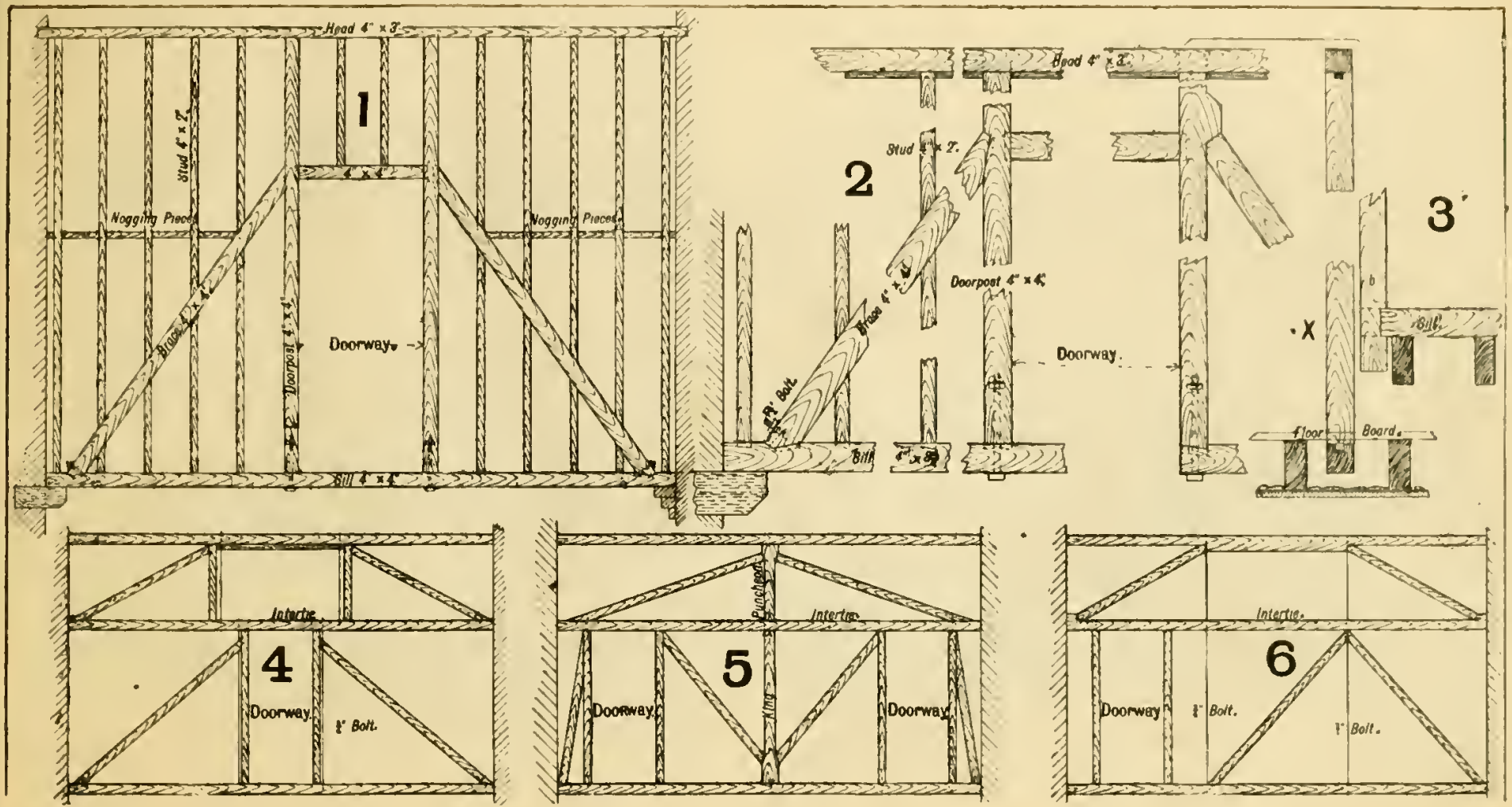
Fig. 6. Shows how the timbers are arranged with a doorway near one side, and a floor on both the head and sill. In the last three the pieces that run from wall to wall (above the doors) are the interties. The studs are to be 12″ apart, but are omitted to show the framework clearly.

Bricknogged partitions are those filled in with brickwork between the studs, which are arranged three, four, or five bricks apart.

Wooden partitions are used in upper rooms, as they are more convenient than brick, and as it very rarely occurs that the tiers of rooms, one floor above another, are all alike, a wall right up is not practicable.

To prevent sound, the partitions are often filled between the studs with sawdust or ashes; this is put in after the laths are on, a small hole being left near the ceiling, or a lath or two left off near the top until they are filled in.

In colleges and studies the first studs are fixed, and then coarse felt nailed over them, and filled in as before; after this, pieces 1½″ square are nailed up the studs, and these are lathed and plastered in the usual way.


Head 4" x 3"
1
Stud 4" x 2"
4" x 4"
Nogging Pieces
Nogging Pieces
Brace 4" x 4"
Doorpost 4" x 4"
Doorway
Sill 4" x 4"
2
Head 4" x 3"
Stud 4" x 2"
Brace 4" x 4"
Doorpost 4" x 4"
Doorway
Sill
3
X
Sill
Floor Board
4
Intertie
Doorway
Bolt
5
Puncheon
Intertie
King
Doorway
Doorway
6
Intertie
Doorway
Bolt
Bolt

ROOFS.

In this plate the three ordinary roofs—couple, collar, and king—are shown, with details for the same.

The wall plate is the piece shown in cross section at the top of the wall. It runs the full length of the building and is generally $4\frac{1}{2}'' \times 3''$, its object being to distribute the weight of the roof equally, the full length of the wall.

The ridge is a piece parallel to the wall plate, and is placed at the apex of the roof; its object is to prevent the spars from moving to and fro, until the slate boards or battens are nailed on.

The common rafters (or spars, as they are called in the North), are the timbers that run from wall plate to ridge, &c., and as a rule are from $3\frac{1}{2}'' \times 2''$ to $5'' \times 2\frac{1}{2}''$, according to length of bearing.

Fig. 1. Shows a section and side elevation of a couple roof; they are called couple roofs when the rafters run from wall plate to ridge, and no cross pieces between. These can only be used for small spans, say up to 12 feet; the wall plates require to be well tied in at frequent cross walls, or an iron rod will be required to go through the wall plates to prevent them spreading.

If a succession of these roofs is used, as over workshops, then the two outside roofs only require tying in.

The pitch of a roof is its inclination to the horizontal plane. In Fig. 1 the wall plates, &c. are in position (the centre of the wall being the best), the eaves to project as shown. Take in your compasses $\frac{2}{3}$ of the depth of spar, and with the top outer edge of the wall plate as centre, describe an arc of a circle. Draw any horizontal line and bisect it between the wall plates, and erect a perpendicular that will pass through the ridge; on the first line at o, set off any two equal spaces, o a, a b, and on the vertical line a space, o c, equal to one of these, then join c and b; and draw a line parallel to it, to be tangent to the circle drawn from the corner of the wall plate. This gives the top edge of the spar; a line parallel at the depth of spar completes the roof to pitch as required.

Fig. 2. This is the collar roof, the pitch is taken at $\frac{1}{3}$. The walls, wall plate, horizontal and vertical lines being given as in the first, set off three equal spaces, as shown, o a, a b, and b c; then two equal spaces on the vertical line, o d, d e, join e c, and this gives the pitch required; draw the top and bottom edge of the spar at the proper place and parallel to e c, and you have a rise of $\frac{1}{3}$ the span.

The collar and rafter are generally fastened as shown by enlarged detail and section; this joint being known as the carpenter's boast. The collar roof is used for spans from 12′ to 18′.

Fig. 3. Shows an ordinary king-post truss. These are used for spans from 16′ to 30′.

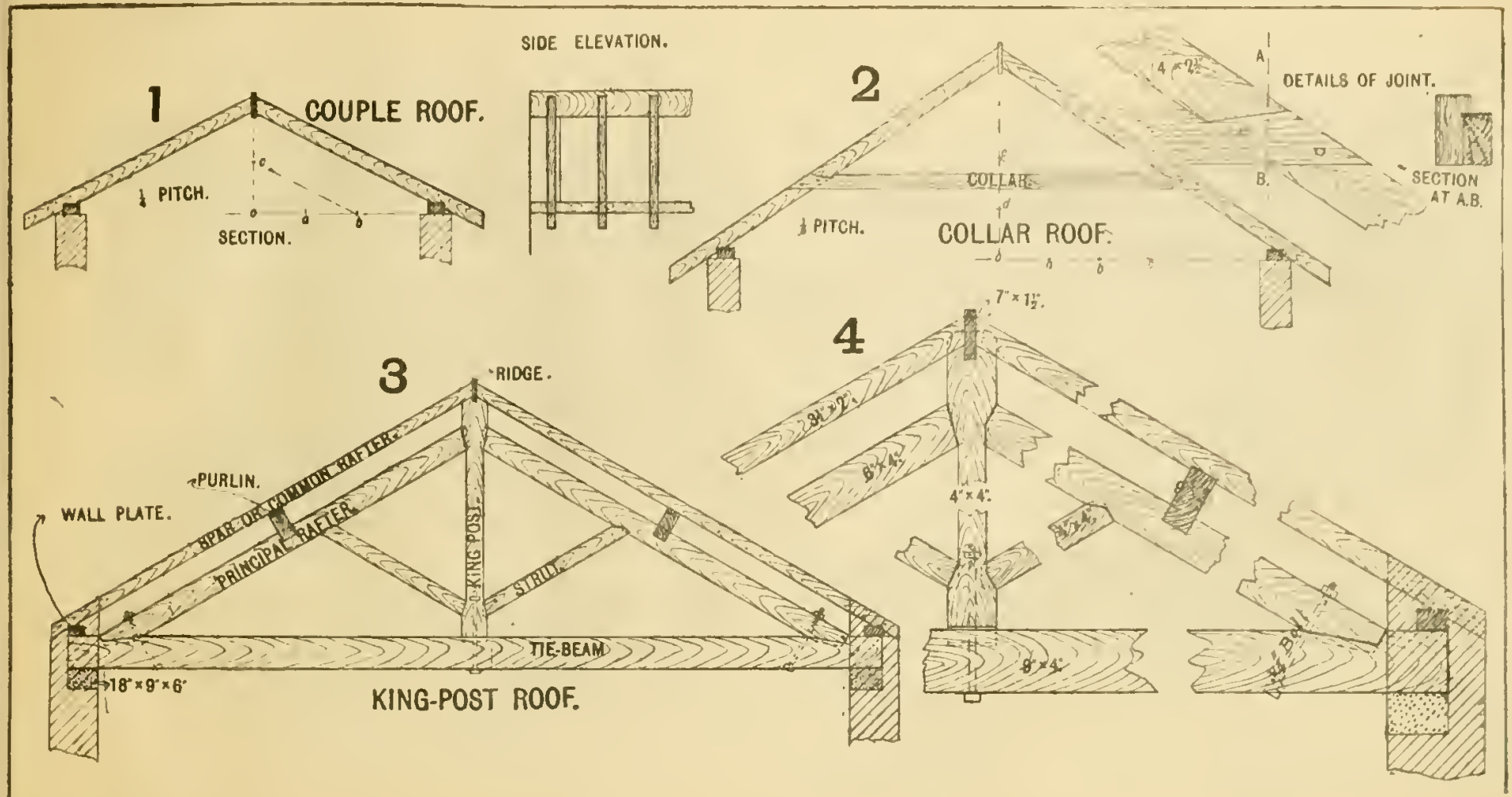
The large piece across the bottom is the tie-beam; the two inclined heavy pieces are the backs; the centre vertical piece, the king-post; and the two small ones branching out one at each side above the tie-beam are the struts. The roof is drawn to an angle of 30°, being a common and convenient angle. The tie-beam rests on stone templates, as a great amount of weight has to be borne at these points.

It will be noticed that the length of the spar is too long from wall plate to ridge, and this is provided for, as shown, by a large piece, called a purlin, running from principal to wall, &c., parallel to the ridge, and resting on the principal back near the strut. This is notched out and cogged on the back, and gives an equal bearing to the spar, above and below.

Fig. 4. The head and foot of the principal rafter are trimmed into the king-post and tie-beam, as shown, and the strut is also prepared as seen in detail.

At the head of the king-post the backs are shown differently, but both are good and practical. The foot of the rafter is secured by a bolt; good plates being used to keep the bolt and nut from eating into the wood when screwing up.

The king-post is cut short, and the tie-beam held up by the bolt; this bends the beam and gives it what is known as camber. It makes the truss rigid and firm, and should be $\frac{1}{4}''$ for every 10′ of length in the beam.


SIDE ELEVATION.
1
COUPLE ROOF.
PITCH.
SECTION.
2
DETAILS OF JOINT.
A
B.
SECTION AT A.B.
COLLAR.
PITCH.
COLLAR ROOF.
3
RIDGE.
PURLIN.
WALL PLATE.
SPAR OR COMMON RAFTER.
PRINCIPAL RAFTER.
KING POST.
STRUT.
TIE-BEAM
18" × 9" × 6"
KING-POST ROOF.
4
7" × 1½"
3½" × 2"
8" × 4"
4" × 4"
8" × 4"

ROOF TRUSSES—*continued.*

In the previous chapter having described roof trusses up to 30′ span, it remains now to touch lightly on one or two for larger spans.

Fig. 1. Shows a common queen-post truss as used for spans up to 45′ The tie-beam, principal backs, struts, wall plates, purlins, spars, and ridges are exactly similar, and arranged like the last.

When there are two vertical pieces the truss is known as a queen-post truss, these vertical pieces being the queens; and the piece between them at the top, marked 9″ × 4″, is the straining beam; and the piece between them at the bottom and on the tie-beam, is the straining sill or piece, generally 4″ deep and the width same as the thickness of the queens.

Fig. 2. Is a front view of the stirrup iron, gibs, cotters, &c., for securing the tie-beam and queen-post together; the queen post is left short as shown, this is tightened up after the slates are put on.

Fig. 3. Shows an enlarged section through the gibs, cotters, &c., ⅛ full size.

The necessary clearance at the top side of the gib in the queen post is marked "space," and the required amount of opening in the strap below the gib is shown at O, O. Without this be attended to, the wedges are likely to be fast, and the joint at the foot of the queen-post cannot be tightened up.

This has been drawn to a large scale in order to show the construction or arrangement clearly.

Fig. 4. Shows a queen-bolt truss, the queen being a wrought iron bolt 1¼″ in diameter. A cast iron box is shown at the junction between the head of the principal rafter and the straining beam, this box receives the two pieces and makes an excellent finish; it will be seen that the top end of the rafter back and the end of the straining beam are both square. This should always be the case if possible.

The joint for the foot of the rafter and the top end of the strut may be secured in the usual way.

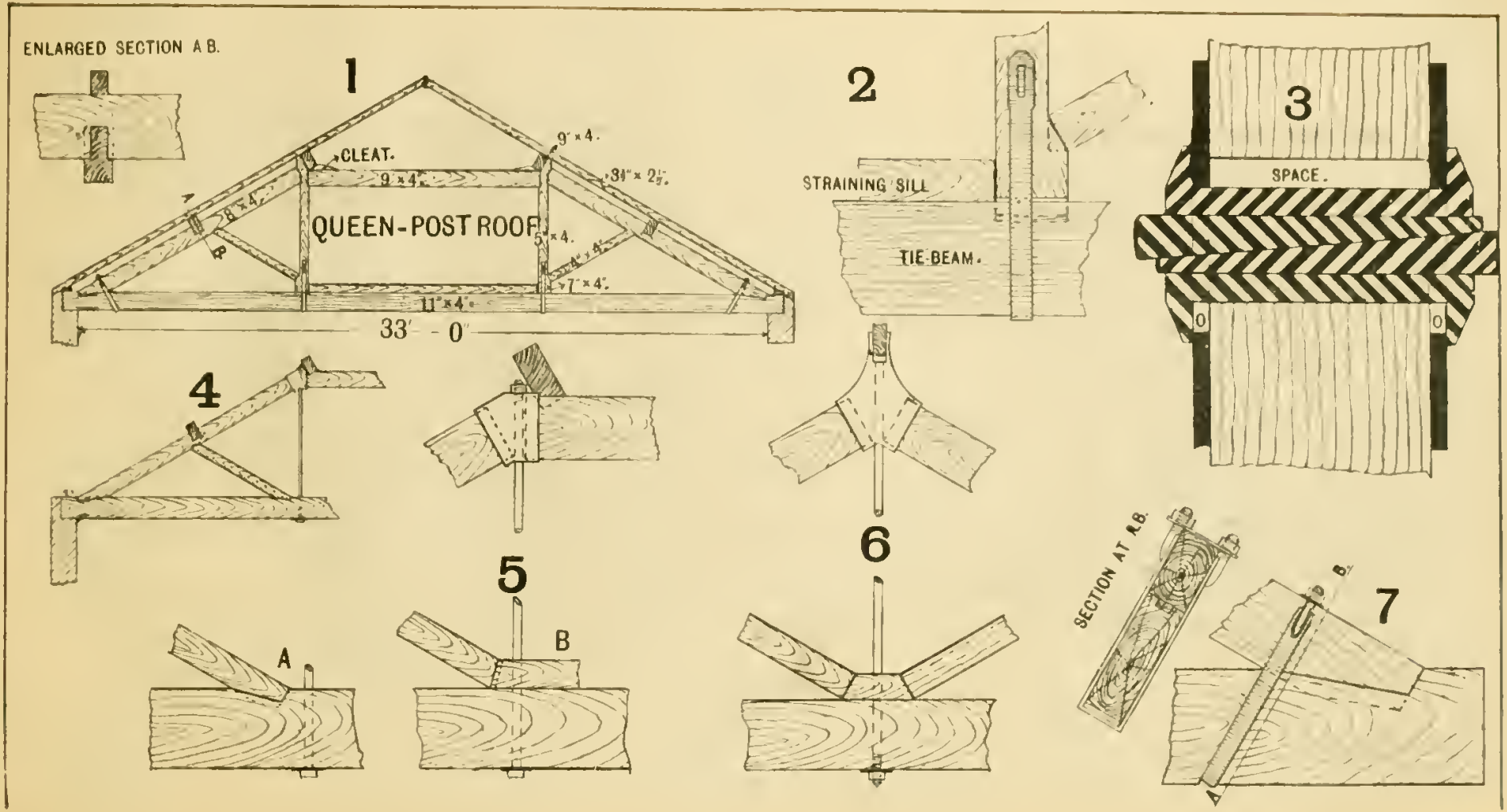
Fig. 5. This is an enlarged detail for the joints of Fig. 4 If a straining sill be used then the joint B would answer for the foot of the strut. Should the strut be trimmed into the tie beam, then the joint A would be used.

Fig. 6. Shows a king-bolt, with cast iron head for the top end of principal rafters, and a notch for the ridge. From the detail it will be seen that the box at the head is so formed that the top ends of the principal rafters are square.

A short piece may be fixed on the tie beam to receive the bottom end of each strut.

Fig. 7. Shows a strap and part bolt for securing a tie-beam and the foot of a principal rafter together. This is an excellent fixing but rather expensive.

The details are large and clear, and only require to be examined to be understood.


ENLARGED SECTION A B.
1
CLEAT.
9" × 4".
9" × 4".
3½" × 2½".
QUEEN-POST ROOF.
5" × 4".
7" × 4".
11" × 4".
33' - 0"
2
STRAINING SILL
TIE-BEAM.
3
SPACE.
4
5
A
B
6
SECTION AT A B.
7

ROOF TRUSS AND DETAILS OF JOINTS.

Fig. 1. Shows a side elevation of a truss for a maximum span of 45′. A queen post truss would answer for a span of this dimension ; as it will be seen from the drawing that the common rafters are supported at two places, in addition to the ends.

The 8′ bearing allowed for common rafters has not been exceeded, as the total length of bearing for these rafters, when the roof has a pitch of 30°, is 24′ 9·112″; and when the two purlins, each 5″, have been deducted, the length of bearing is 7′ 11·702″, or a fraction less than 7′ 11¾″.

The following sizes are used : Tie beam, 11″ × 6″; backs, 7″ × 6″; purlins, 9″ × 5″; ridge, 7″ × 1½″; wall-plates, 4½″ × 3″; struts (two longest), 6″ × 4″, two 6″ × 3″; king-bolt, 1¼″ diameter; next two (the queens), ¾″, and the two short ones (princesses), ⅝″. The heel bolts are ⅞″ diameter.

Fig. 2. The details of the main joints are shown to a large scale, which is given on the sheet.

The tie beam has a wall hold of 9″, the stone pad is 3′ long, 9″ × 4″. The foot of the rafter is forked to fit the web in the iron plate, see elevation section at C D, and plan The two nibs, one at each end of the plate, which are let into the beam are 4″ broad ; this prevents cutting right across the beam. When the end of a piece of timber is forked out in this manner it forms a bridle joint.

The purlins have cleats at the underside to prevent them from canting over. These are shown 3½″ deep, and a stump tenon, 1½″ deep at the bottom, and tapered out to the purlin. These cleats are 6″ broad, and the stump tenon is 2″ broad. When the purlins are let down into the backs—say two-thirds of their depth—the cleats are not required.

The joints at the top ends of the struts will be understood by examining the drawings.

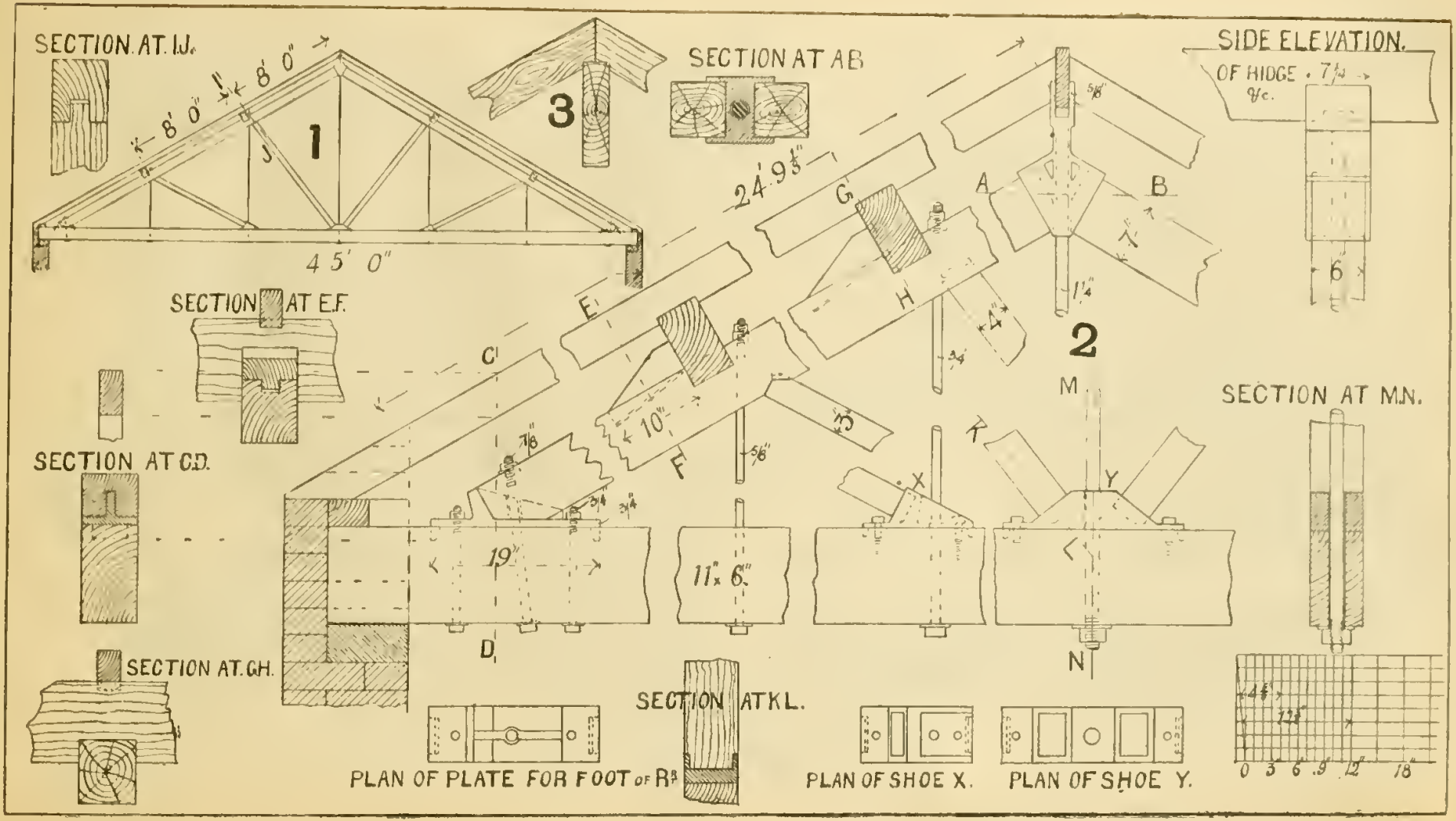
The top ends of the backs are secured in a cast-iron box or head ; the metal is ⅝″ thick, and is pierced to keep it light, and, at the same time, leaves sufficient metal where strength is required. The head is prolonged and prepared for the ridge. See side elvation.

The foot of the lower strut is secured by a cast-iron shoe. The vertical bolt, the two ⅝″ coach, and the two nibs (one at each end) prevent any moving of the strut. See elevation and plan of the shoe.

The two centre struts are secured in a double shoe ; the elevation, plan and section being shown.

Fig. 3. Shows how the spars are to be cut and secured to a heavy ridge, and in this case the ridge is 12″ × 3″.

For sizes of any parts of details not figured the scale must be used.


SECTION AT I.J.
8' 0"
8' 0"
1
J
4 5' 0"
3
SECTION AT AB
24' 9⅓"
G
A
B
5/8"
7"
1¼"
4"
3/4"
2
SIDE ELEVATION.
OF RIDGE 7¼ &c.
6"
SECTION AT E.F.
E
C
H
10"
F
5/8"
3"
7/8"
3/4"
3/4"
19"
11" x 6"
D
SECTION AT C.D.
SECTION AT G.H.
SECTION AT KL.
X
K
Y
M
N
SECTION AT M.N.
PLAN OF PLATE FOR FOOT OF R^B
PLAN OF SHOE X.
PLAN OF SHOE Y.
0 3 6 9 12 18"

ROOF TRUSSES.—*Continued.*

Fig. 1. Shows half elevation of a wooden roof truss for a span of 50′ between the walls.

In this, the purlins are arranged so that the bearing distance shall not exceed 8′. In order to do this, the second or centre purlin is placed below the queen post; and the top purlin is so placed that it gives an equal bearing for the common rafter, from the ridge to the next purlin. The distance between the queens is 20′, and the small king post prevents any sagging.

The sizes being figured on the various parts, and the joints and fastenings of the ordinary type and explained before, these need not be repeated. The only exception being the joint of the head of the queen.

Fig. 2. Shows the detail to the same scale as the details for the last plate. The straining beam end is cut square, and assisted by a cleat 10″ deep, the width of the queen and 3″ projection. This is stump tenoned and secured to the queen by two ¾″ coach screws.

Fig. 3. Shows how the tie beam is to be secured to the queen, if a room is to be formed between the queen posts. The strap secures the whole together; the lower back and straining beam may be increased in strength, as extra strain is thrown on those by the weight of floor. In the present case a room, 8′ 6″ high, may be arranged, except at the beams, where the head room would be 7′ 9″.

The breaking weight of such a beam as this tie beam, when used as a girder, would be about 21½ tons.

Fig. 4. Shows how the principal backs are to be secured to the king post when the head of the king post is cut in a line with the top side of principal rafters.

Fig. 5. Shows part elevation of roof truss suitable for a span of 65′ between the walls. The construction for the joints is similar to the last; but for very large spans a second back is often used in the lower part: this is known as a cushion rafter, or back. It is difficult to get these two backs to bear equally. The queen posts are the same distance apart as those in Fig. 1, and the tie beam is suspended at a second point by the ¾″ bolt. A wooden post may be used if necessary. These next the queens are called princesses.

Fig. 6. Shows the details for the head of the queen, and the foot of the rafters with the end of the tie beam; the latter joint is secured with a stirrup iron, gibs and cotters: see section of these. The cotters are ½″ thick, and a strip of iron, ½″ thick and 1½″ broad, is placed under the gibs to give a broader bearing surface. Straps are often used for the other joints, *i.e.*, for top of the queen straining beam and back; but, this part being in compression they are not necessary.

Fig. 7. Shows a side elevation for a curb or mansard roof. These roofs are used when a room is required in the roof; or where the law as to right of light is in force, or for architectural effect.

There are two distinct pitches. A common rule for determining these is shown: draw the semi-circle and divide half of this into five equal parts, as shown; from the base take the second point as the top side of the upper tie beam, and the centre as the bottom side of the lower beam. The small king post truss at the top is formed by joining the highest or centre point to the second from the base. The details for this small truss are of the usual kind.

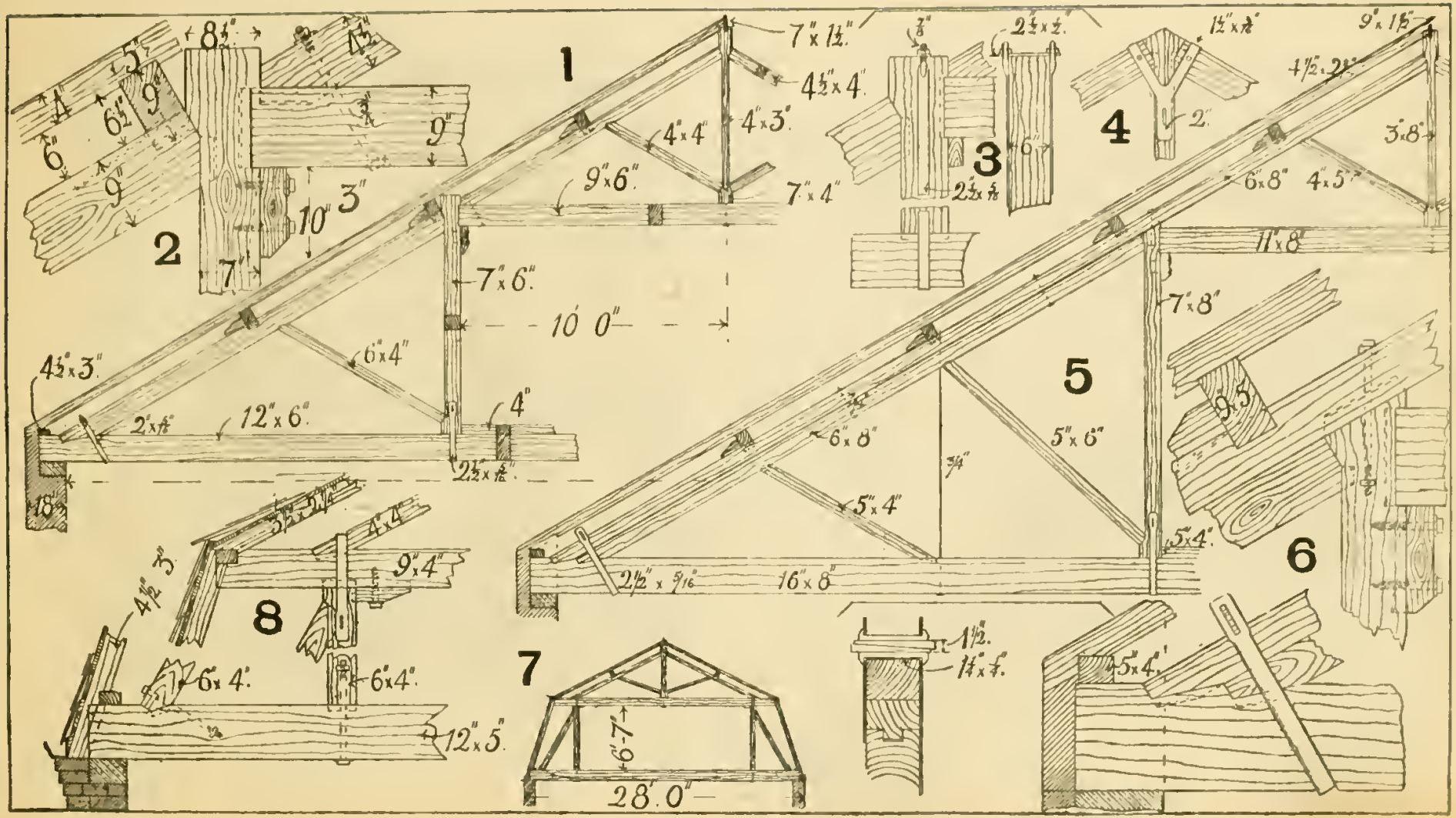
Fig. 8. Shows the details for the main joints; the upper plate is arranged to receive the head of the lower rafters and the foot of the upper rafters. Straps or bolts may be used at the discretion of the designer.

The finish at the eaves is also a matter of opinion; but the arrangement shown prevents the possibility of water from the gutter finding its way inside to the same extent as it would if a parapet wall had been used.

The names of the various parts are not marked on the members, as the student at this stage will know each without.

In all these the main details are large and the principal scantlings figured, at the same time these are capable of considerable modifications without exceeding the limits of practicability.

The students are advised to look over the rules given showing how to find the length of rafters, king posts, &c.; also the formula for determining the scantlings for various parts of roof trusses; and when any doubt exists, it is better to err on the side of excess than reduce to a minimum. Remember that a well-constructed roof is one of the best ties for a building, whereas a faulty-constructed or too light a roof is one of the surest methods of pushing a building asunder.


1
2
3
4
5
6
7
8
7" x 1½"
4½" x 4"
4" x 3"
4" x 4"
9" x 6"
7" x 4"
7" x 6"
10' 0"
6" x 4"
4½" x 3"
12" x 6"
4"
2½" x 5/16"
18"
9" x 1½"
4½" x 2½"
3" x 8"
6" x 8"
4" x 5"
11" x 8"
7" x 8"
5" x 6"
6" x 8"
5" x 4"
5" x 4"
16" x 8"
2½" x 5/16"
9" x 4"
4" x 4"
6" x 4"
6" x 4"
12" x 5"
6'-7"
28'.0"
1½"
5" x 4"

SKYLIGHTS.

Fig. 1. Shows a section plan and elevation of a small skylight on a slate roof. Scale 1″ to 3′.

The light is hinged to a casing 1½″ thick, and the depth sufficient to cover the common rafters, and receive the plaster, and to keep the skylight at such a height that it would lie flat on the slates when opened. The casings are deep and have a slight sinking in the centre to break the plain surface.

The elevation and plan show part of the rafters and the trimming for the skylight.

Fig. 2. Shows a section through one side. Scale 1″=1′. The skylight is 3″ thick and prepared for the glass as shown, with a mould on the inside. The stile and top rail have each a ⅜″ groove into which a hardwood fillet ¾″ deep is fitted. This forms a good, cheap, and secure joint to prevent the water from finding its way into the inside.

The slates are shown 2″ from the frame forming a gutter at the side; sometimes they are taken close up against the frame; both are practicable and right.

The lead flashing it will be seen passes under the slates (not less than a couple of inches) turned up against and over the top edge of the casing.

Fig. 3. Shows a section through the full length of the skylight, the hinge is fixed to the top rail and casing, the knuckle is let into the hardwood fillet. The centre of the hinge must not be too near the lead on the casing, otherwise the skylight will not open. The minimum distance from the frame being half the projection over the lead.

The bottom rail is thinner, which allows of the glass passing right over, and at the same time leaves a place for the exit of any condensed water.

A is a section through the top rail minus the hinge; this shows the ¾″×⅜″ fillet referred to before. The roof boarding is 7″×1″. The details are large and will be understood by examining the drawings.

Fig. 4. Is a section through the top and bottom rails of a skylight which is fixed; these are much cheaper than the last, but are only for light, and cannot be used for access on to the roof, or for ventilation.

Fig. 5. Shows a section through one side of the skylight, showing how the lead is arranged to keep out the wet. At the side the lead is in short lengths and kept in line with the tails of the slates. The top end of each piece is covered 3″ by the next above it. The scale for these details is 1″=1′.

B is part plan of such a skylight (scale 1″=3′) showing the lead, trimming, &c.

Iron skylights are the cheapest and answer very well where they are not much exposed; the objection is the iron stain on the slate. No lead flashings are required.

Fig. 6. Shows the plan of a small skylight. In order that they may be fixed to the roof boards, there are two ears at the top and one on each side.

The hingeing is arranged by projections on the flange and corresponding pieces on the sides of the iron sash, a ¼″ or $\frac{5}{16}$″ bolt passing through from side to side.

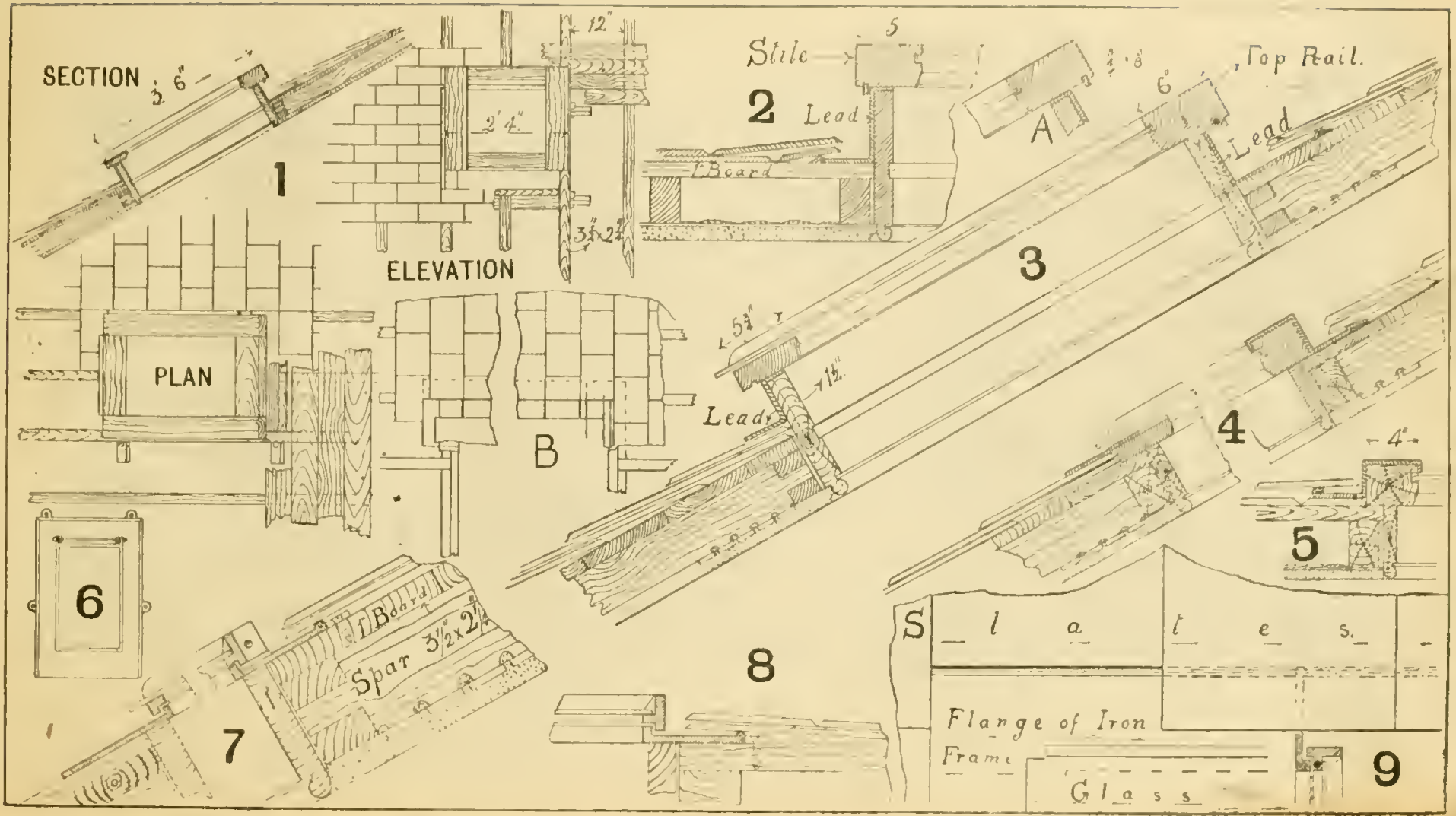
Fig. 7. Is an enlarged section through the top and bottom rails. The bottom end is kept up so that the slates pass under the flange at the bottom; this flange and the one at the top are about 4″ broad and ¼″ thick. At the head and sides a small head is shown: this prevents the water finding its way inside. The inside may be covered with an inch casing.

Fig. 8. Shows a section through a side of the same light. The slates are shown over the bead both in this and at the top of the light in Fig. 7.

Fig. 9. Shows the plan of the bottom flange and part of the side. This illustrates the method of arranging the slates to keep out the wet. A section through the side is repeated to show how the plan is projected.

The cheapest method for lighting common buildings is to have large squares of strong glass inserted with the slates; no frames being required. Another method, skylight bars, tapered off at the top end and nailed on the common rafters, form a very cheap and secure provision against wet, without frame or lead flashing, and may be any length and width.

For skylights to staircases, billiard rooms, and similar places, having moulded hips, ridges. *See Special Chapters.*


SECTION
1
ELEVATION
PLAN
B
Stile
2
Lead
Board
Top Rail.
A
Lead
3
Lead
4
5
6
7
Board
Spar 3½x2½
8
S l a t e s.
Flange of Iron Frame
Glass
9

CENTRES.

Centres are the temporary structures for turning brick, stone, or other arches over. They are usually made of slabs about 1″ thick, except where they are very large, then they are made out of scantlings, the size of which depends upon the weight they have to bear, &c.

Fig. 1. Shows an elevation of a centre for a segmental arch when the rise is such that each side of the centre may be made of one slab as shown.

The two sides are cut to the required curve, less the thickness of the laggings, these are fixed together on the under side by the two cross pieces shown above the wedges over the props, and marked A. The top edges of the sides are secured by laggings, which are generally $1\frac{1}{2}'' \times 1''$ and fixed about $\frac{1}{2}''$ apart for brick arches.

In this figure only a few of the laggings are shown.

Fig. 2 is a section through Fig. 1, the wall being 14″ it will be seen that the lags are about 13″ long, this allows a line to be stretched on either side of the wall; at the same time the lags are long enough to turn the arch over.

Fig. 3. Shows how a centre for a semi-circular arch may be built up for a span of 12′ or so. In this the laggings are shown a good distance apart; they are used in this manner when the arch is in large stones. If for a brick arch the construction is the same, except that the lags are close together as in Fig. 1.

Fig. 4. is a vertical section through Fig. 3. and would require props, wedges, &c. similar to the one just explained.

Fig. 5. Shows how a centre for a large span may be constructed by forming it into triangles.

In these the joints are generally secured by iron dogs, as shown.

Props, &c., would be stronger in proportion to the extra size.

Fig. 6. Shows how to prepare for an inverted arch. These are used under pillars and where shop fronts and similar openings occur.

In the present case a bed of concrete is put in, the soil having previously been removed to a depth of not less than 9″, a rough scantling (marked A) is propped up to the centre from which the invert is struck, and a trammel in the shape of a T aquare is fixed and worked backwards and forwards until the concrete is a true segment as required. A portion next the brickwork is finished with finer stuff (see drawing). Only the outline of the inverted arch is shown.

Fig. 7. Shows a section through Fig. 6 with trammel, cross section of the scantling with the pin on which the trammel works, concrete, &c. The wall is shown 9″ thick, and the depth of the inverted arch is figured 9″.

Fig. 8. Shows how the foundation for the bottom half of a circular arch is prepared for. The bottom half is built up and a plank laid across the opening, this is kept so that the centre of the trammel will work in it; in this case the trammel is shown at one side.

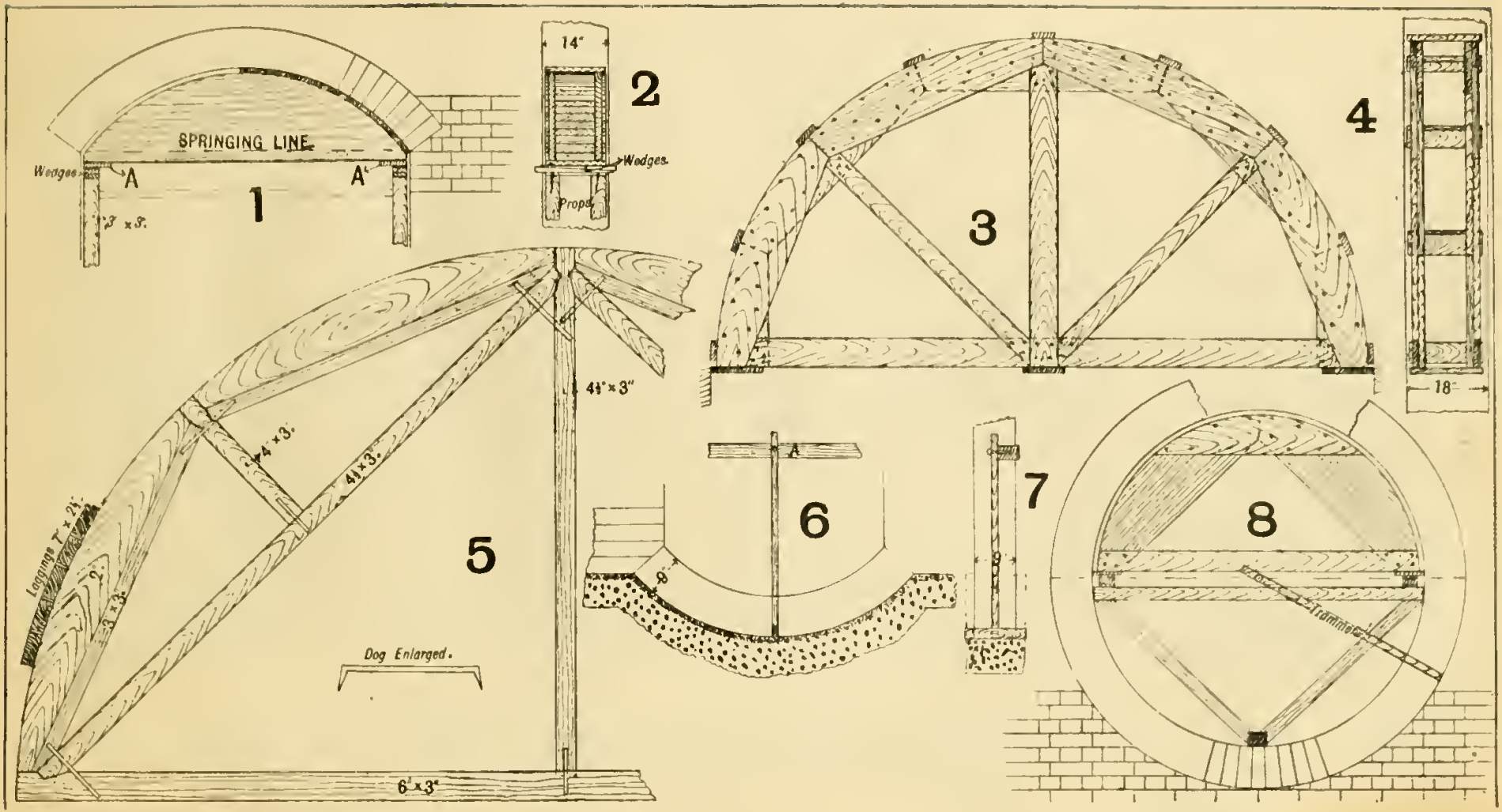
The length of the trammel must equal the radius of the opening; add depth of arch and mortar joint.

The bricklayer having built up to where the arch has to begin, he lays his brick in position allowing for the bed and vertical joints, then taking hold of the trammel, he marks the brick, then lifts it out and cuts it to the required shape, and then beds it properly and finishes it. This is repeated until he reaches the centre, when his trammel and scantling are removed.

The arch is built from the bottom; two or three arch bricks are shown. The arch is built to the springing line, and then a centre is fixed as shown, the bottom of this is a fraction above the springing line, so that the centre may be easily got out when the wedges are slackened.

For centres to ordinary brick arches, the wedges should be slackened as soon as the arch is finished, and then it allows the bricks in the arches to find their bearings.

The arch should not be set in quick-setting mortar, or it cannot accommodate itself to any little irregularity caused by slackening the wedges. The centres must not be finally removed until the mortar is thoroughly set.


SPRINGING LINE
Wedges
A
A'
1
3" x 3".
14"
2
Wedges.
Props.
3
4
18"
4½" x 3"
4" x 3".
4½" x 3".
Laggings 7" x 2½"
2" x 3".
5
Dog Enlarged.
6" x 3"
A
6
9"
7
8
Trammel

DOORS.

The doors in this book are of tha very commonest description, and in fact it is only by a stretch of courtesy that the first receives the name.

Fig. 1. Consists of two different parts, the vertical boards known as battens, and the horizontal pieces known as backs or ledges. The boards are sometimes left square and no beads, V's, or grooves and tongues. In others they are grooved and tongued, beaded, or V jointed, as the case may ho.

The ledges are generally three in number, as shown, from 4″ to 7″ broad and 1″ to 1½″ thick; these frequently have a bead or chamfer taken off to remove the sharp arrises.

Fig. 2. Shows four similar views of a ledged and braced door, tha ledges being 6″ × 1″, the bracea 4″ × 1″.

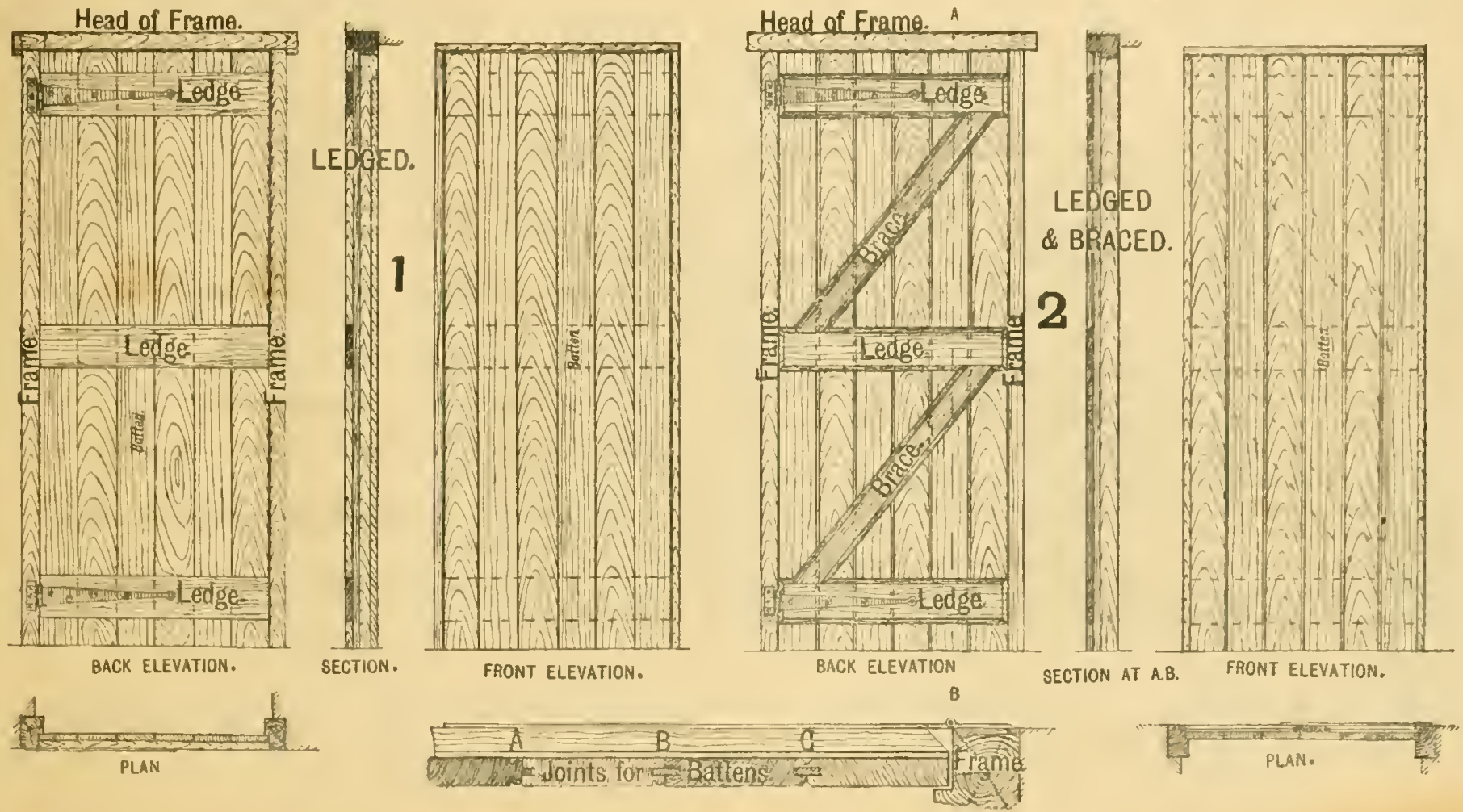
In hingeing a door of this class, care must be taken to put the hinges on the sides shown.

In putting these doors together, the boards are nailed to the ledges with wrought nails and clenched, three naila in the outside boards and two in each of the othera.

These doors are used for yards, W.Cs., callara, &c. If for a yard door they are often hinged with bands and hooks, the hook being run into a stone built into the wall; these stones are at the proper heights, so that, when a band is screwed on each ledge, top and bottom, they are right for the hooks that are run into the stones. At the opposite side, near the centre, another stone is built in, to which a staple, and sometime a staple and catch combined, ara run in with lead, and auawers for the catch if a latch be nsed, and for the bolt to slide into, it heing usual to have a flat bolt on the middle ledge.

When a wooden frame is used, then the frame is generally a solid one, 4½″ × 3″ or so, and rebated out ½″ on and the thickness of the door, or, as shown at Fig. 1, to the thickness of both board and ledge, and hinged with ordinary T hinges.

A front and back elevation, section and plan of this door, are shown.


Head of Frame.
Ledge
Frame
Ledge
Frame
Batten
Ledge
BACK ELEVATION.
LEDGED.
1
SECTION.
Batten
FRONT ELEVATION.
PLAN
Head of Frame.
A
Ledge
Brace
Frame
Ledge
Frame
Brace
Ledge
BACK ELEVATION
B
LEDGED
& BRACED.
2
SECTION AT A.B.
Batten
FRONT ELEVATION.
A
B
C
Joints for Battens
Frame
PLAN.

C

DOORS *continued.*—

In Fig. 1. is shown front and back elevations, with plan, and an enlarged detail of the joints, for a framed, ledged and braced door. This door is shown for a yard, and is not rebated into the frame. If for an internal or better class door, then the frame must be rebated for the door.

The stiles, which are the vertical pieces up each side, and the top and bottom rails are 2″ thick, the first three being 6″ and the last 10″ broad; the lock rail being 9″×1″, and the braces 4″×1″; sometimes the braces are omitted.

In order to give a neater and lighter appearance, the framework is chamfered and stopped, both above and below the lock rail; the top edge of both lock and bottom rails are chamfered right through to prevent a ledge for dust, &c.; this is often done when all the other parts are stopped.

The boards are grooved into the stiles, head and bottom rail, as shown in enlarged detail; the boards are V jointed, ploughed and tongued, as seen in cross section.

It will be observed that a portion of the stile at the top and bottom, is left on; this is as the door would be finished at the bench, and this piece, along with the haunching shown, prevents the stile ends from splitting. The haunching is the piece of tenon cut off on the top side of the top rail, and the bottom side of the bottom rail, see drawing; its object is to leave sufficient strength in the stile ends when the door is taken to the proper length.

Fig. 2. Shows an enlarged detail of a stile, and part of the top, middle, and bottom rails, with a horizontal section showing a stile and part of the boards.

The haunchings in all the rails are shown, and marked H; and also the wedges.

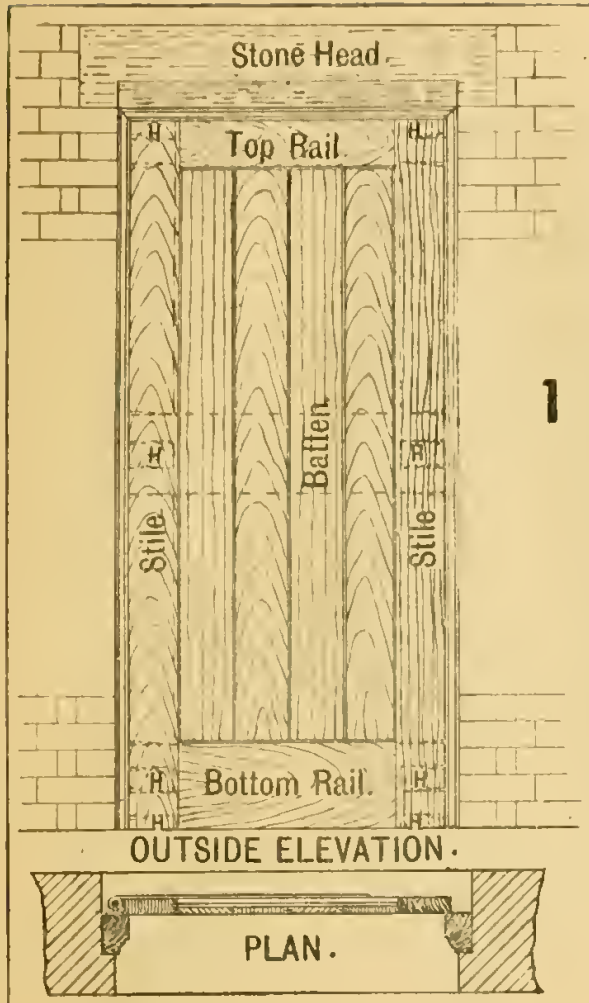
Fig. 3. Shows a vertical section to the same scale.

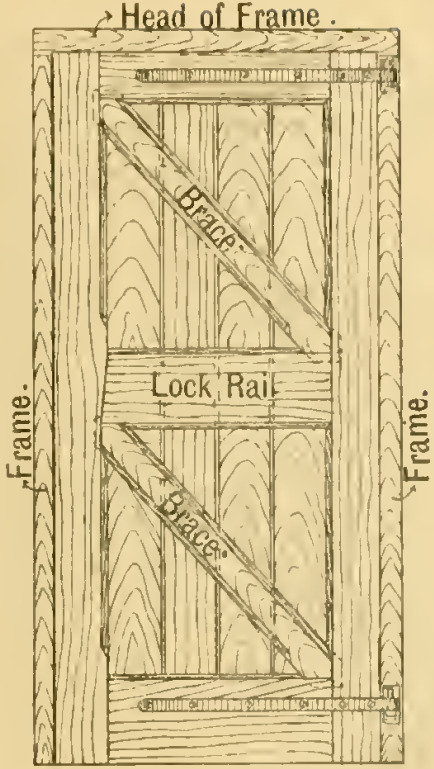
Fig. 4. Shows the edge of the door when finished.

Fig. 5. Shows a section through a bottom rail when rebated and bevelled to throw off the water.

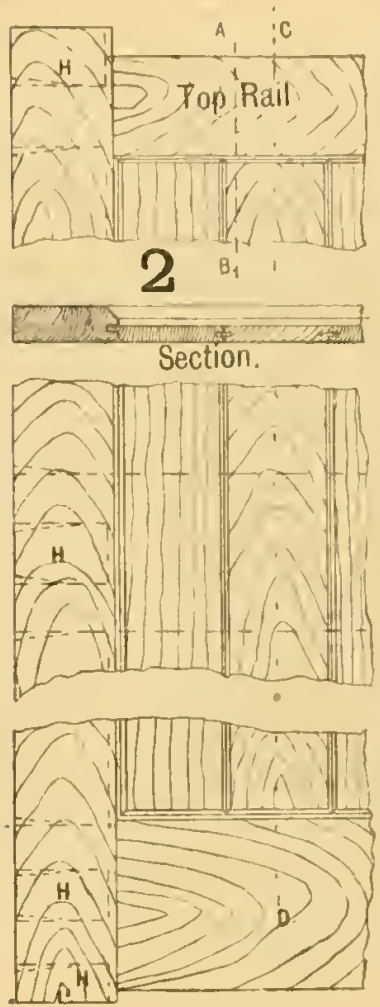
Fig. 6. Shows a section when the boards run right over the bottom rail, similar to the lock rail.

Fig. 7. An enlarged section through the top rail is shown, the mortice being in dotted lines.





INSIDE ELEVATION.



DOORS *continued.*—

Fig 1. Shows an ordinary four-panelled door. They are made of various thicknesses from 1″ to 2½″, this door being taken at 2″.

In order to save room, six different methods are represented on one door, four on the first view and two on the second. The outside vertical pieces are the stiles, the centre (narrow ones) muntins, and the thin pieces between the muntins and stile are the panels.

For very ordinary doors no moulds or chamfers are used ; they are known as square and flat, shown at the top left-hand panel. The next one is chamfered and stopped, in some cases they are moulded in addition to the chamfer. In the bottom panel, on the left is shown an ordinary sunk mould, and that to the right a raised or bolection mould ; these are shown in the enlarged horizontal section.

In fitting these into the door, they are carefully mitred at the angles, and then all driven in tight, and, at the same time, a slight bevel is given to the back edges, in order that they may tighten as they go down. Then they are sprigged to the frame, care being taken that no sprigs get into the panel, as they tend to split the same if any shrinking takes place.

The other view of the door shows that a bead is run up the full length each side of the top panels ; this is known as head butt. The two bottom panels have the head run all round, and is known as bead flush ; the first is much the cheapest and often used in common work ; the other has to have a piece rebated out at the top and bottom of the panel where it runs across the grain, and then a small bead mitred and planted in this rebate, so that the head may intersect with the one on the panel. In some cases a similar appearance is obtained by running the bead on the frame work, and mitreing it at the angles. In this, as seen in section, the panels are 1″ thick, and flush on one side.

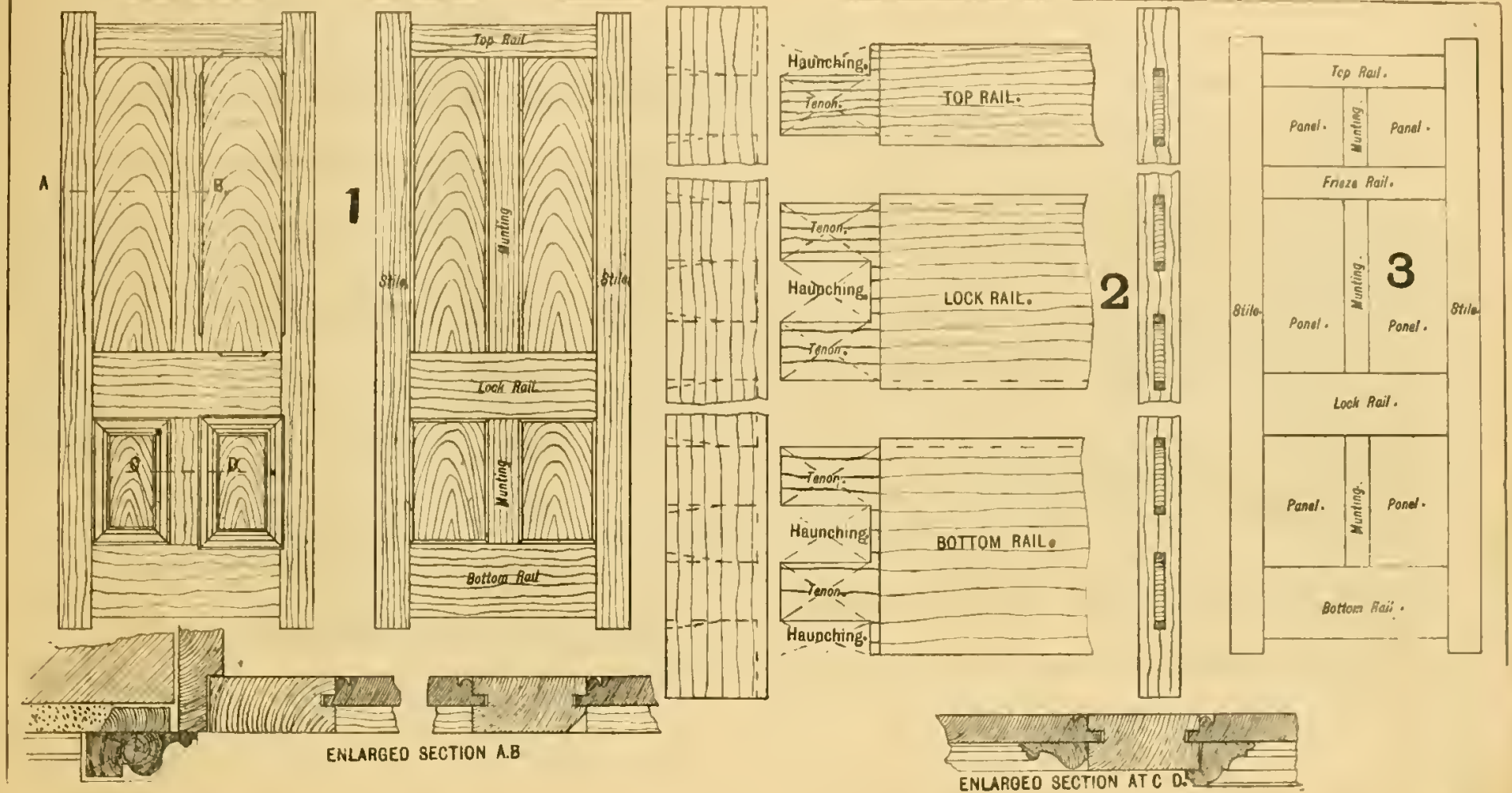
The doors are generally hinged with two hinges, one just below the top rail, and the other just above the bottom rail, to a frame or casing 1½″ thick, rebated out as shown, these casings are often fixed to plugs in brick walls ; but a better plan is to build in hardwood fillets, or pallets.

A common finish is shown to this door. First, a ground is fixed round the opening, both sides and head ; this is fixed to the wooden pallets ; their ends project slightly out beyond the brickwork and are cut off to a plumb line, then the ground is fixed to these, which plan is shown in the horizontal section. It is 2½″ broad and ¾″ thick : this gives ⅞″ for plaster ; the reason is that brick walls are not perfectly straight, and this allows a little for the uneven surface of the wall. The outside edge of the ground is bevelled and kept just within the edge of the architrave, so that whilst it makes a good key and level surface for the plaster to work to, the architrave covers the joint between the plaster and ground.

These grounds are sometimes grooved for the key on the back edge. If not fixed plumb and true they are useless and misleading. In works more elaborate and expensive, these are often framed. A small block is fixed at the foot of the architrave, scribed to fit the floor, and as high as the square on the skirting ; the skirting fits against this and the back of the architrave if it be not housed in.

Fig. 2. Shows enlarged details for the joints between the rails and stile. The names are on the rails, hannchings, tenons, &c., and are clearly shown, both side and edge view being given.

Fig. 3. Shows a six panel door. The names are on the various pieces ; these are put together in a similar way to the four panel doors. The lock rail is the usual height to the centre 2′ 8″ to 2′ 9″.


A
B
C
D
1
Top Rail
Stile
Munting
Stile
Lock Rail
Munting
Bottom Rail
Haunching
Tenon
TOP RAIL.
Tenon
Haunching
LOCK RAIL.
Tenon
2
Tenon
Haunching
BOTTOM RAIL.
Tenon
Haunching
Top Rail.
Panel.
Munting
Panel.
Frieze Rail.
Stile
Panel.
Munting
3
Panel.
Stile
Lock Rail.
Panel.
Munting
Panel.
Bottom Rail.
ENLARGED SECTION A.B
ENLARGED SECTION AT C D.

DOUBLE MARGIN DOOR.

Fig. 1. Shows a plan and elevation of a double margin door. Doors of this class are made wide, and in such a manner as to match with ordinary folding doors.

The door is first framed in two separate pieces, and secured together afterwards by three pair of hard wood fox wedges, as seen in elevation. These are put in, the first pair 3″ from the top rail, and then a pair 3″ from the bottom rail, and a third pair just above the lock rail in the middle. They require to be at these distances, so that there may be sufficient timber between them and the ordinary mortices to resist the pressure when these wedges are tightened up.

The tenons are the usual thickness, ⅓ to ¼ of the stiles, and the hardwood wedges are the same. Having prepared the stiles and rails in the usual way, and the two centre stiles being morticed for the extra keys, proceed to glue up the doors minus the panels, care being taken that you only glue the centre stile and the rail ends that go into this; then put on your cramps and wedge this stile on.

Having served the other half in the same way, dress off the ends of the tenons and prepare the joint for the centre; next, glue your joint and wedges, and cramp the two up, and drive the hardwood wedges as tight as necessary; remove your cramps and the outer stiles; dress off any surplus length of hardwood wedges in the grooves, and put in your panels and wedge on the outside stiles as for an ordinary door. Moulds, &c., may be used to suit the class of work.

Fig. 2. Shows a section ½ full size through the joint between the centre stiles, when the joint is rebated as in this case, the beads are stuck on the solid.

Fig. 2a. Shows a groove and cross tongue, with a small piece rebated out, and a seperate head planted over the joint. In this the stiles ars narrower than the other, if any shrinking takes place it is hid under the bead.

Fig. 3. It will be noticed that the casings are rebated on both sides of the wall; this is usual in good work, and where framed casings are put in, it gives a neat and uniform finish.

The casings are trenched together at the head, that is, the soffit is trenched the same depth as the rebate, and the head of the jambs prepared for it and then nailed together.

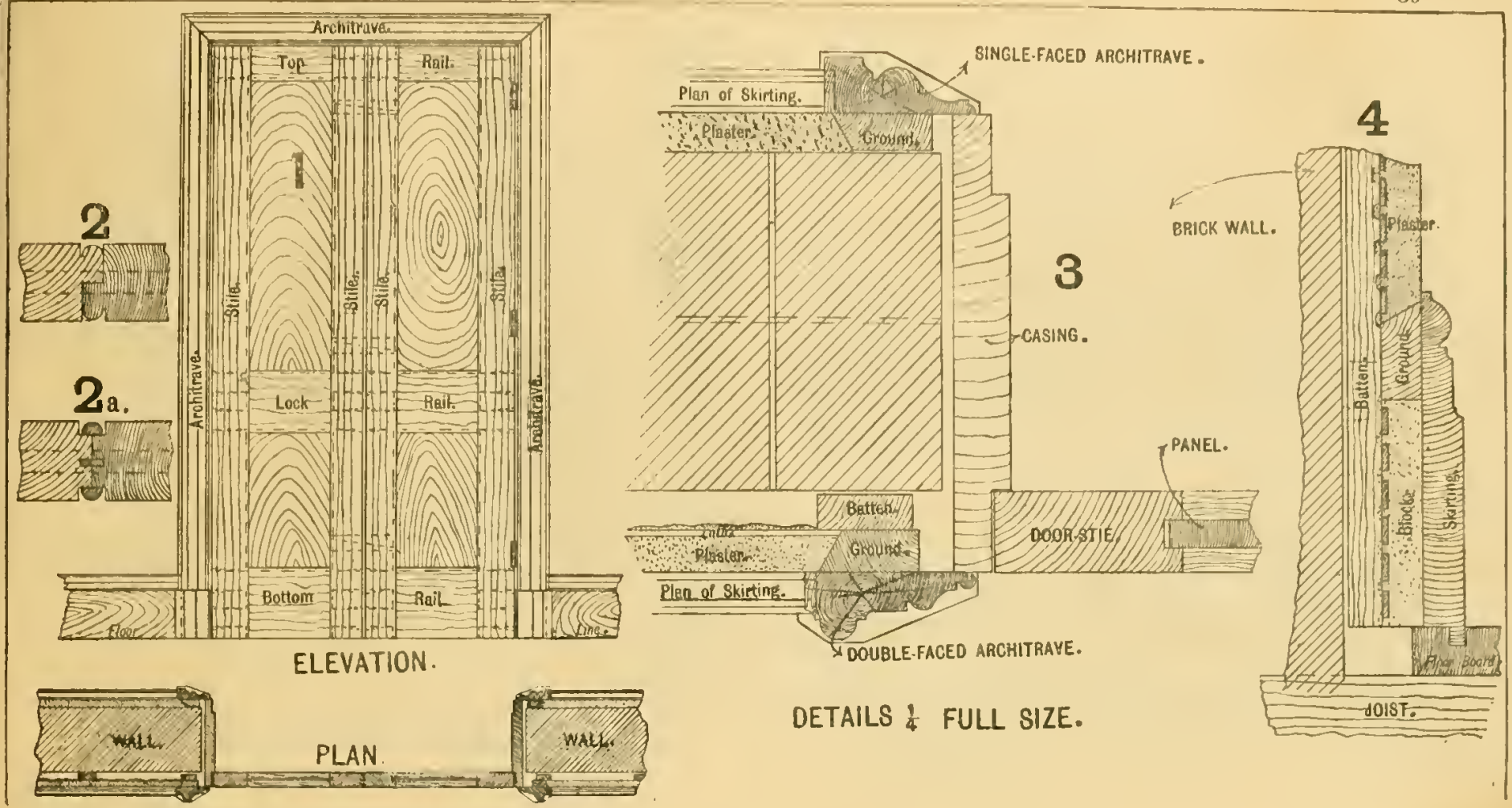
When against an outside 9″ wall in an exposed situation, the walls are often battened as shown, vertical pieces like studs are used 2″ broad and from ½″ to 1¼″ thick, 12″ apart and secured to plugs. On these the laths are fixed and then plastered.

The architraves are shown, that on the nearer side being a double-faced one and that on the further side single-faced. These are fixed to grounds (as before described), and mitred at the top; in very good and massive work, cross tongues are used and handrail bolts to give extra security to the joint. The block for the foot of the architrave is shown, the blocks are usually the same height as the square on the skirting.

Fig. 4. An enlarged section of the skirting with ground to fix the same to, is shown; the portion under the grounds has upright blocks every 18″ or so, down to the floor; these are to keep the skirting from twisting.

The space between these blocks should be filled in with rough mortar.

The skirting is shown grooved into the floor; when this is done, then it only requires nailing at the top edge. The skirting is housed into the blocks and back of architrave as shown, and at internal corners it is trenched, and the moulds scribed one on the other; for external corners they are mitred and nailed.



DETAILS ¼ FULL SIZE.

WINDOWS.

This chapter is devoted to a common sash and frame, and a few enlarged details.

Fig. 1. Shows an elevation (half inside and half outside), a horizontal section or plan, and a vertical section.

In the present case the window is fixed in an ordinary 14″ wall, 4½″ reveal, 4½″ recess, and 9″ jamb, the last being finished with 1″ linings, grooved into the casing and nailed to pallets built in the jambs (as explained before) and a mould or architrave runs round and is mitred at the top.

These window frames are bedded in good hair mortar, or oil putty, the last is often used for the sills only. The frames are fixed with fox wedges at the ends of the sill and at the top, right over each pulley stile, a piece being packed on the top, so that the wedges may act direct on the pulley stiles, and not on the inside and outside casings only, no nailing being required.

Linings similar to those shown may be used, or plaster, finished with an angle bead.

Fig. 2. Shows an enlarged vertical section with broken lines to show the details as fully as possible.

Fig. 3. Shows a horizontal section through one side of the frame and sashes, to the same scale as Fig 2. The frames and sashes are made of all sorts of timber, from oak to white deal.

The staff beads are 1¼″, and the inside casing 1″, the joint between the pulley stile and casing is hid; these beads are sometimes rebated into the frame.

The pulley stiles are trenched into both head and sill, and frequently wedged in the latter and then nailed; the inside and outside casings are nailed to both sill, head, pulley stiles and back-lining, this last is often nailed on the outside edge. The parting slip, to keep the weights apart, passes through the head of the pulley stile, and is suspended by a nail through it, on the head of the last-named piece; this parting slip is cut off 3″ above the sill.

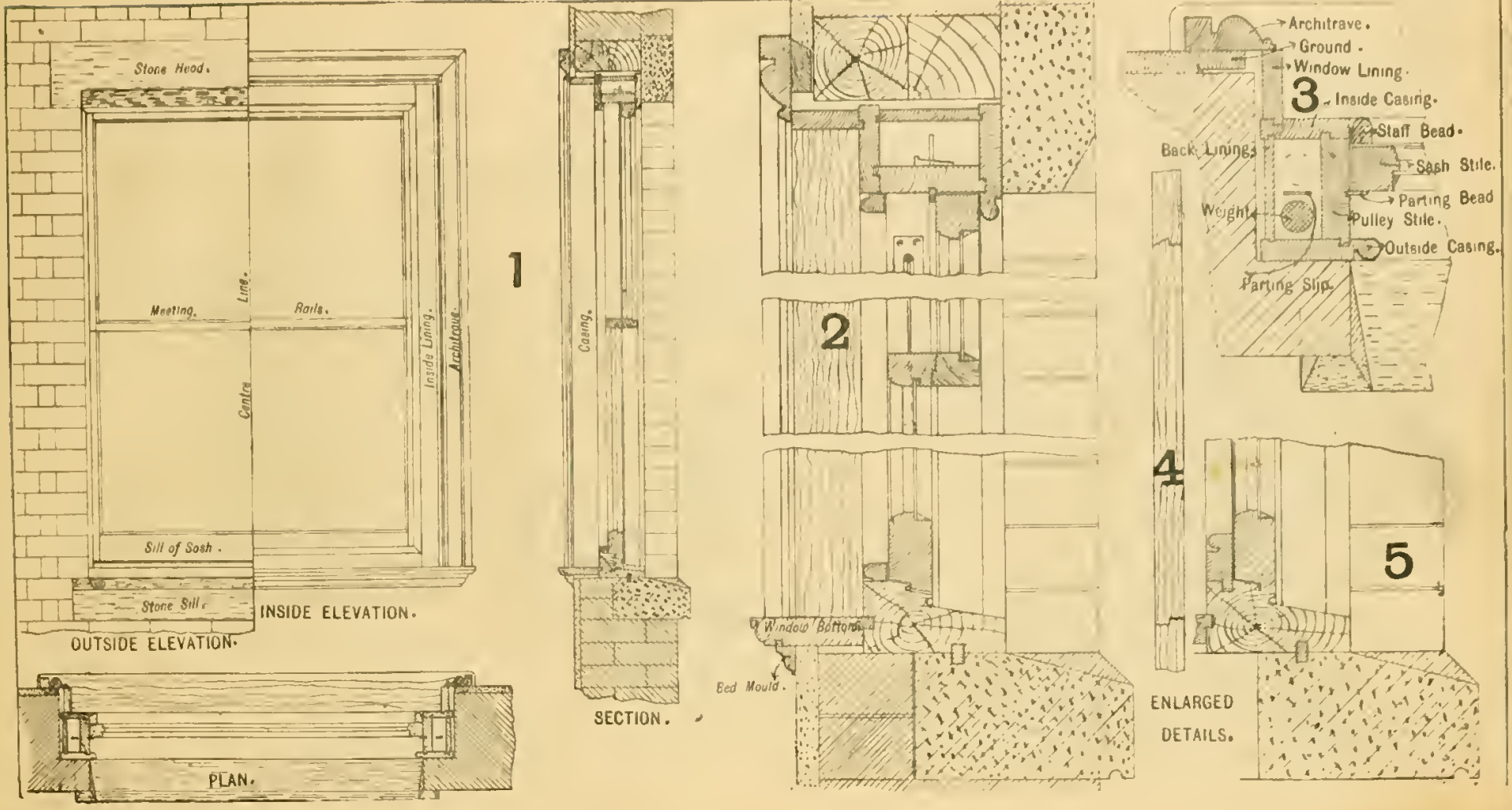
What are known as the sashes, are the two frames in which the glass is put. An average size for stiles is 2″ and the head the same; the sill is a little deeper; the meeting rails are 1½″ thick. The side pieces are called stiles. The top and bottom rails are tenoned into the stiles and dovetailed at the meeting rails. If horns are left on the stiles these last may be tenoned and morticed together. The meeting rails are rebated as shown in vertical section, and prepared for the glass by a groove in the lower and a rabate in the upper rail.

Double-hung sashes are suspended by cords which pass over pulleys, one end of the cord being fixed to the weight and the other into a groove in the stile; the weight of the sashes being obtained when the glass is in. In order that the top sash may be held up against the top, and the bottom sash slightly rest on the sill, the weights for the top sash should be 2lbs. more, and those for the bottom 2lbs. less than the sash.*

Fig. 4. Shows an enlarged vertical section through the pocket; a place in the pulley stile below the meeting rails has to be prepared to get the weights in and out at; this aparture is the pocket, and is about 2″ wide and of length to suit the weight, it is rebated at the bottom, and rebated and bevelled at the top, as shown in detail.

Fig. 5. Shows an enlarged section through the sill of a frame prepared as the last, for window board or bottom; and metal tongue; and double sunk for the sash with an extra groove for a deep bead on the sill as shown. This is to allow the bottom sash to be raised, and admit fresh air at the meeting rails, without causing a draught at the bottom. They are usually secured by spring catches on the inside, to prevent them being opened from the outside.

* *The best method the author knows of, for hanging sashes, is the one patented by Mr. J. H. Jones, Cheetham Hill, Manchester.*


Stone Head.
Meeting.
Line.
Rails.
Centre
Inside Lining.
Architrave.
Sill of Sash.
Stone Sill.
INSIDE ELEVATION.
OUTSIDE ELEVATION.
PLAN.
1
Casing.
SECTION.
2
Window Bottom.
Bed Mould.
Architrave.
Ground.
Window Lining.
3
Inside Casing.
Staff Bead.
Back Lining.
Sash Stile.
Weight
Parting Bead
Pulley Stile.
Outside Casing.
Parting Slip.
4
5
ENLARGED
DETAILS.

DOUBLE SASHES, &c.

It will be seen at a glance that the double sashes are made up of two bottom and two top sashes.

This class of window is used for offices, banks, &c., as they prevent the noise from the street being heard. They also keep a room warmer in winter and cooler in summer, in addition to these advantages they keep the room much cleaner, as the principal part of the dust settles between the two bottom sashes and may be collected from there instead of having to dust it up in the room from chairs, desks, &c.

The above qualities are in favour of such windows, but they are expensive.

Fig. 1. Shows a vertical section through the sill of such a window, the width being limited, the sill may be in one piece as shown.

Fig. 2. Shows a horizontal section through one side of the same window.

The staff bead E is sometimes rebated in as shown.

The details are clear and need no further explanation.

Fig. 3. Shows a vertical section through a similar window where more room is available, and an improvement may be made by placing the sashes further apart.

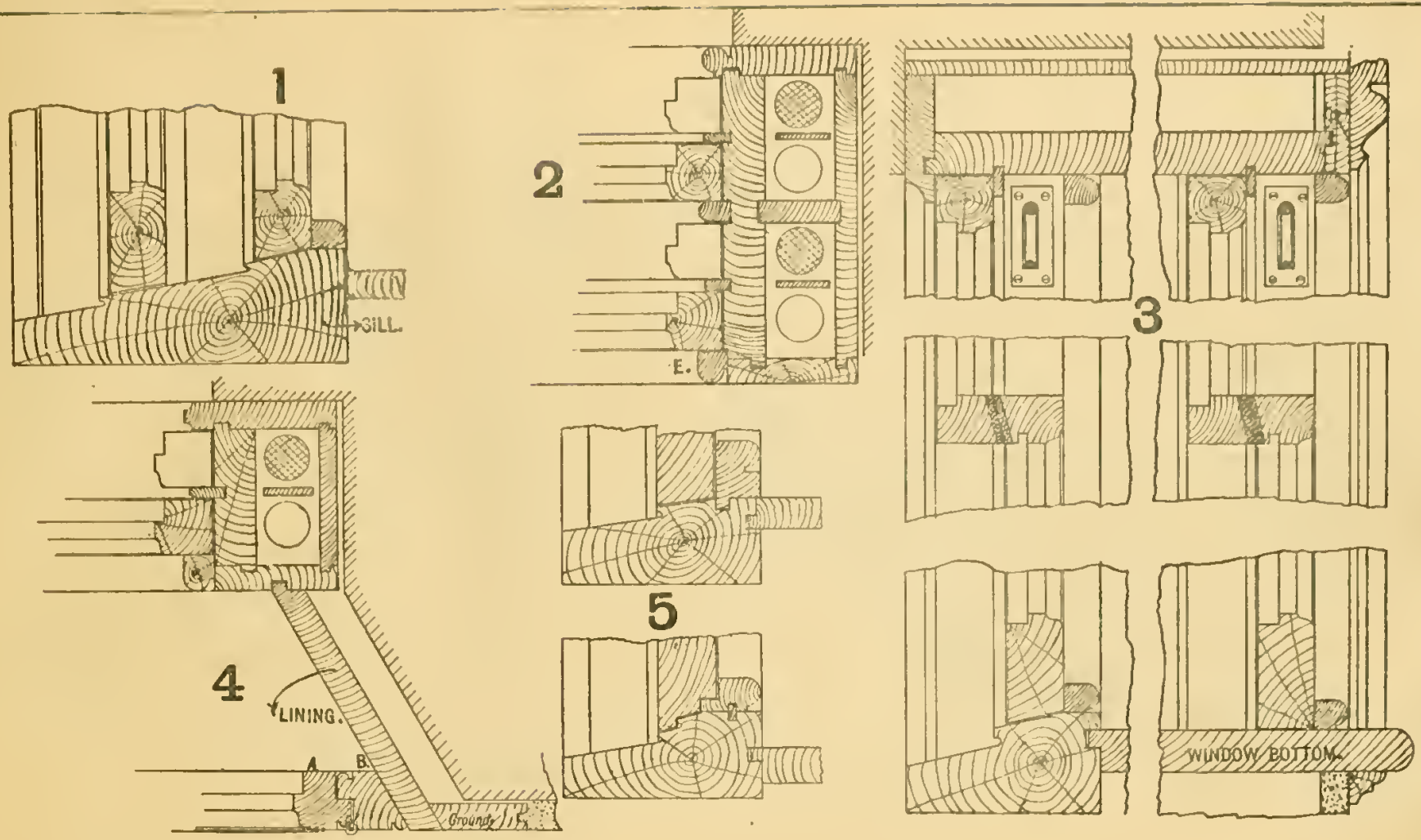
When very wide sashes are used and no vertical bars put in, the meeting rails are liable to be sprung off the glass, these may be stiffened by screwing pieces of brass on as shown between the meeting bars, these strips of brass are equal in length to the distance between the parting beads.

Fig. 4. Shows how a casement may be fitted and hinged to an ordinary window, which would answer the same purpose as the double sashes.

The above windows may be finished in the usual way with moulds, architraves, &c.

Fig. 5. Shows two methods of finishing ordinary sills, the object being to keep out the wet. The first has a deep bead grooved into the sill, and shows the method of finishing the joint between the window bottom and sill, when the two are to be level on the top side.

The second shows how the wet may be kept out by an extra rebate in the sill and bead as shown.


1
SILL.
2
E.
3
4
LINING.
B.
Ground
5
WINDOW BOTTOM.

WINDOW SHUTTERS.

These are almost out of date now; they were originally used for protecting the house from burglars, and also for keeping the rooms warm in the winter.

The examples given are taken from actual measurements.

Fig. 1. Shows the plan of a three-light window, the 14″ pier being used to carry the revealed portion outside.

In this case it will be seen that provision had to be made inside the pier to receive the shutters when they were folded back, this is obtained by framing the front and on the opposite side to the shutter, this is known as the boxing, and is arranged, as shown, to match the shutters. The one that is hinged to the sash frame is known as the front shutter, the others are called back-flaps; these are rebated and hinged as shown. The principal part to attend to is to see that the shutters will cover the window opening, and that they are arranged so as to be easily got in and out of the boxing.

It will be seen that the centre light has shutters hinged to each side, whilst the shutters to the two side lights are hinged to one side only.

In each of these they are folded back in the boxing, and shown in faint lines as they would be when closed at night.

They are usually fixed by a flat iron bar hung on a centre to the back of one of the flaps, and when the shutters are folded in the boxing, this bar hangs behind the shutter.

It will be seen that Fig. 1 shows the shutters at right angles to the face of the frame, this is the case when sufficient space can be obtained without bevelling the sides.

Fig. 2. Shows a case when the sides are bevelled in order to let the light penetrate into a corner, and also to prevent it being dark behind a broad pillar between two windows, &c.

In this case sufficient room is obtained by bevelling, together with the small piece at the back of the architrave, to admit of the window being covered by the shutter and one back-flap.

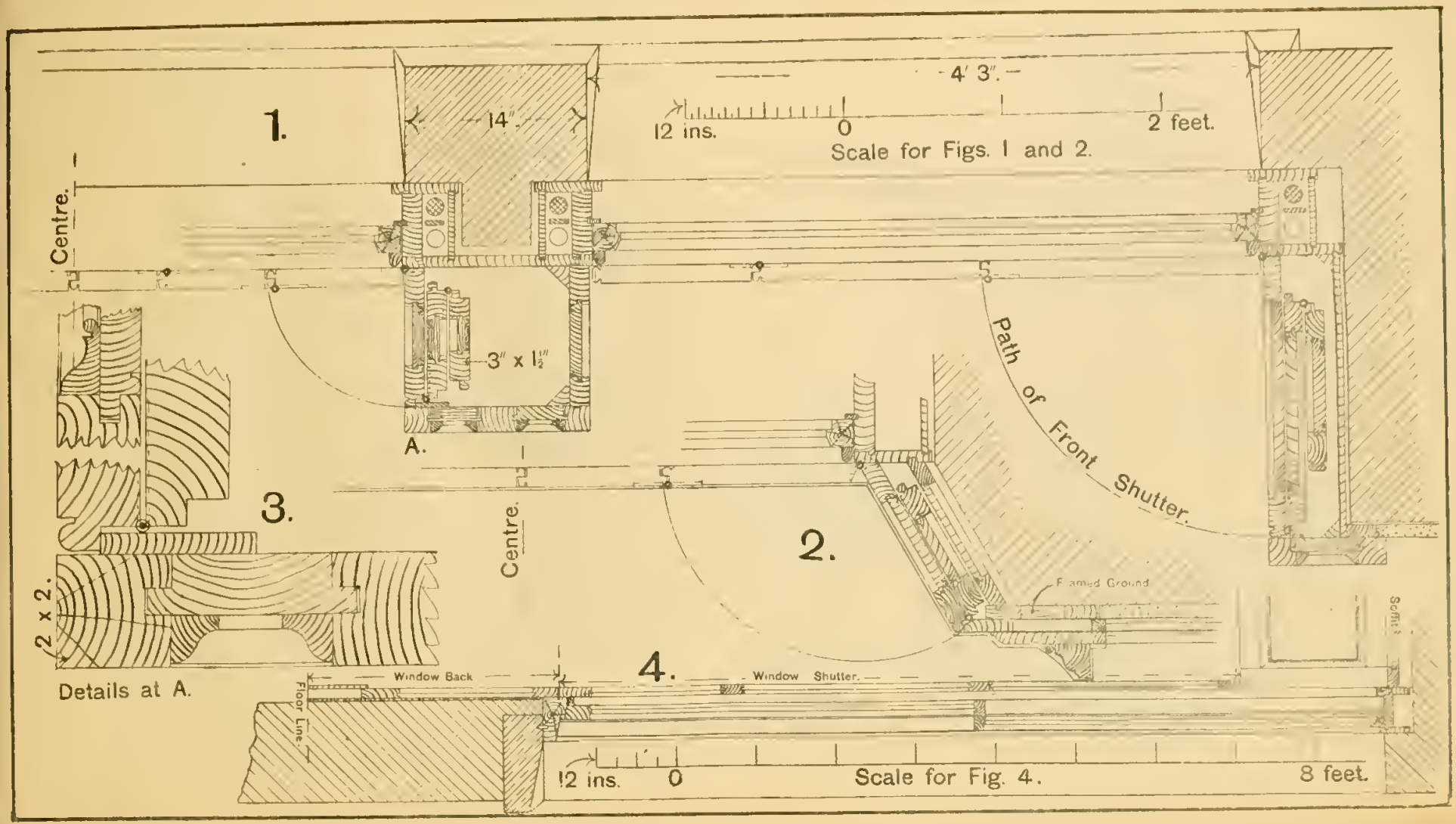
In this it will be seen that a broad architrave is used, and a framed ground is fixed to receive the back-lining and plaster.

The back-lining is framed, but they are often plain as shown at Fig. 1.

Fig. 3. Shows an enlarged detail for the angle A Fig. 1.

Fig. 4. Shows a vertical section through the window, shutters, window back, &c. This is to a reduced scale.

The details are clear and the arrangement will be understood by a perusal of the plate.


1.
14".
4' 3".
12 ins.
0
2 feet.
Scale for Figs. 1 and 2.
Centre.
3" x 1½"
A.
Path of Front Shutter.
3.
Centre.
2.
2 x 2.
Framed Ground
Soffit
Details at A.
Window Back
4.
Window Shutter.
Floor Line
12 ins.
0
Scale for Fig. 4.
8 feet.

CASEMENT WINDOWS.

Fig. 1. Shows a vertical section through a casement hinged to the stile and prepared to open outside. The frames for these are as a rule solid, made of oak, pitch-pine, red-deal, &c. The wooden sill of this is rebated to fit a stone sill, sunk, weathered and throated. In the inside they may be finished with moulds, casings, &c., like an ordinary sash-frame.

The frame itself is put together at the corners with tenons and mortices, and fixed as a sash-frame by fox wedging. They may be left square, chamfered, or moulded to any pattern. The casements are morticed and tenon-jointed, and the moulds scribed or mitred at the angles.

In these the great difficulty is to keep out the wet. In the sill this is met by a rebate and double sinking, the sinkings being very deep, and the lower one throated; at the head and sides a deep rebate is formed and a small throating.

The casements are fixed by any ordinary fastening on the inside.

Fig. 2. Shows a horizontal section through Fig. 1. The jamb or stile of the frame is rebated and moulded similar to the head. The stile of the casement is shown, and the hinge in its proper position.

The details are large and clear, and will be easily understood by a perusal of the plates.

Fig. 3. Shows a vertical section, when a transome is used and a fanlight formed above, and a casement below. The transome is the heavy piece the full thickness of the frame, and runs from side to side, or from side to mullion; a mullion being a vertical piece from sill to head, &c., and may be stone, brick, wood, &c.

These are hinged to the side as shown at Fig. 2, but in this they open inwards. Any wet getting in at the fanlight is caught at the transome, and passes out through a hole bored in the same about the centre of its length. The hole is shown by dotted lines. For the casement a similar provision is made in the sill; fully shown in detail. The sill of the fanlight has an extra width to form a weathering, and may be used for the sill of the casement, if it be not too expensive. The fanlights are sometimes hinged to the transomes.

Fig. 4. Shows a vertical section through a casement hung on centres, the casement is shown open by dotted lines. These are often used where ordinary casements and sashes are difficult to get at, as the former can be opened and closed by a cord. It will be seen that the top end goes into the room, and the bottom end outside; and should be kept at an angle similar to the one at which it is shown. Generally this is managed by a light cord fixed to the frame and the head of the casement. Then any rain beating on it, when open, will run outside. The centres on which it works are fixed a little above the middle so that it tends to keep shut.

It will be seen that at the head, in addition to the rebate, a bead is planted on the outside of the head, and one on the inside of the sill. These are fixed to the frame and the small pieces mitred to them, and cut, as shown; then on the outside a piece is nailed on the stile of the casement, and opens with it. This is in dotted lines. On the inside the bead is run all round, and cut to allow the casement to open. The head at the head and the parts on the sides are fixed to the casement, and the one at the bottom is fixed to the sill; and the remaining pieces on the frame. When the window is closed it appears one continuous bead.

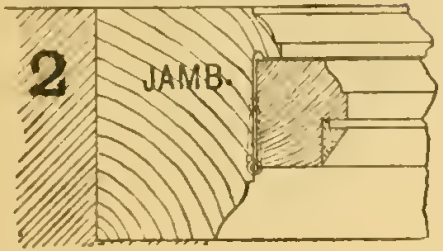
To determine the necessary bevel at the head, for the casement to open, draw a line from the centre to x, then lay your square on this line and it will show the necessary amount of splay required from x to y; make the rebate in the head to this bevel and the casement to fit, and it will clear.

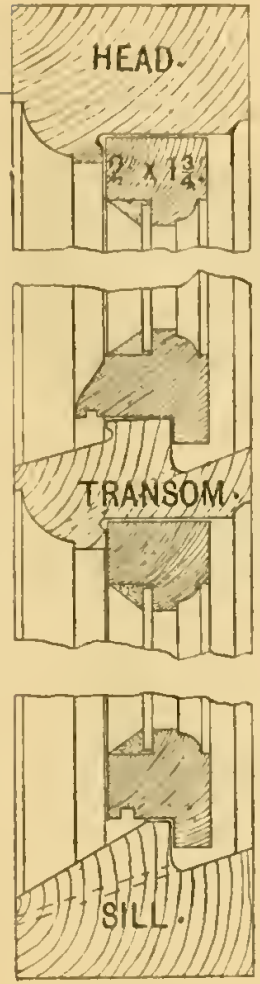
To cut the beads, draw the casement open with the beadlines on, then from the centre to a draw a line, and make this line and the line a o at right angles, *i.e.*, square; b o is the same, and a′ o′ and b′ o′ show the points when open.

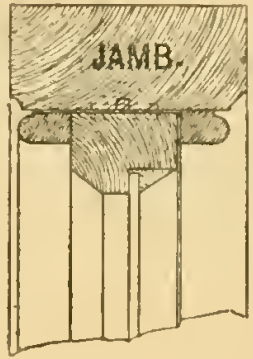
Fig. 5. Shows a section through one side of the frame, casement, and heads.

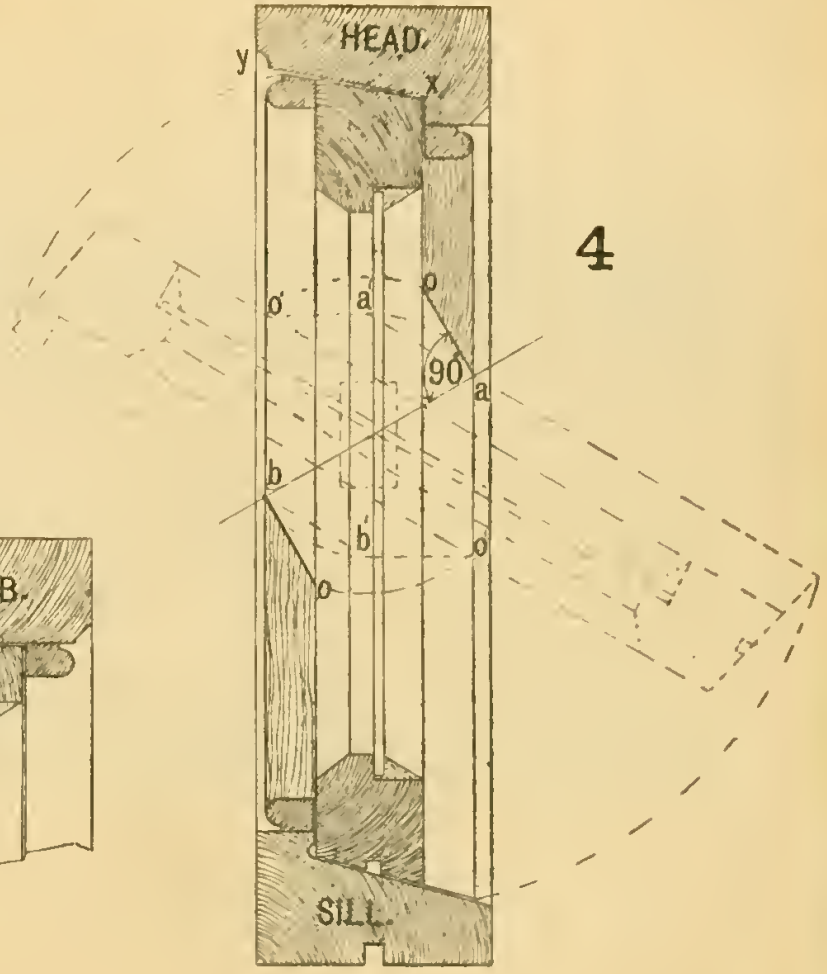
Note.—In each of these examples, the width of the head, sill, and jamb is 4½″

HEAD.
1
SILL.


2
JAMB.


HEAD.
2" x 1¾"
3
TRANSOM.
SILL.


5
JAMB.


y
HEAD.
x
4
o'
a
o
90
a
b
b
o
o
SILL.

WINDOWS—*continued.*

Fig. 1. Shows a plan or horizontal section through a Yorkshire light, and a section at A B. These are used when a sufficient height cannot be had for ordinary sashes and frames, or where a common casement opening inside or outside would be inconvenient. It will be seen that the frame is a solid one, and bars are let into one half, the two sides being rebated for the glass. The other half is a loose frame, which slides along a tongue at the bottom, and between the rebate and bead at the top (see section at A B). A groove is run up one stile, and there is one to correspond with it in the frame; a tongue is fixed in the latter and then the other slides on this, and with the bead planted on the frame makes a secure joint.

The best method for these sliding sheets is to have a metal tongue and two pieces of brass grooved out to fit the metal tongue; then they are let in to the bottom rail, the wood being clear. Brass $1'' \times \frac{3}{4}''$, fixed one at each end close to the stiles.

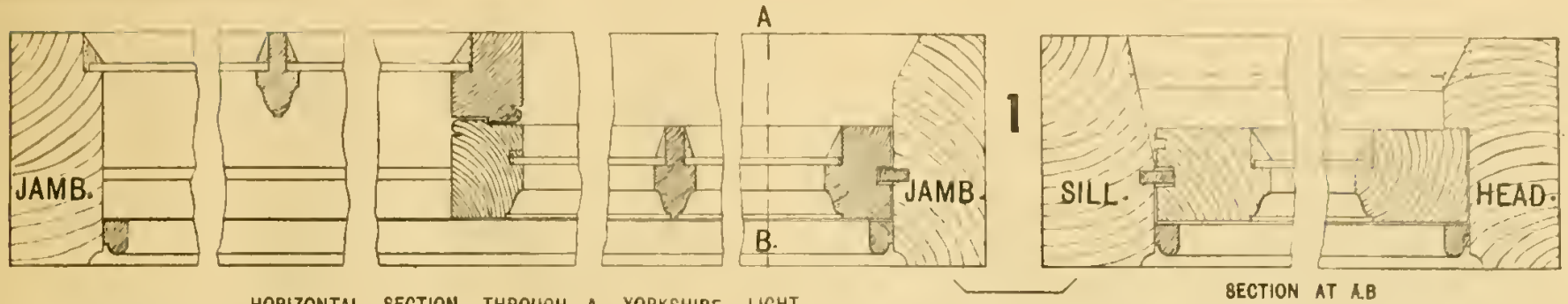
The frame is put together with tenon and mortice joints, in some cases the head and sill run through, and the stiles are tenoned into them. The sash is secured at the corners in the usual way.

Fig. 2. Shows a section through a French casement, or glass door, these are hinged to the side and as a rule are made folding. They are used for access to balconies, conservatories, &c., the sills being close to the floor. In addition to the hanging stiles being rebated into the frame, a semi-circular projection is left on, to assist in keeping out the wet. At the meeting stiles a secure but expensive joint is shown. The head and sill are prepared exactly as those for the casements that open inside.

Fig. 3. Shows the usual method of mitreing sash bars together. When both horizontal and vertical bars are used, then they have to be jointed and either scribed or mitred. In chamfered window bars, and a few common moulded ones, it is possible to let both run through. The bar that has to resist the greater strain ought to be left whole when one only can be put through. The joint on the top-side of the bar shown in cross section is the one in common use when cut, the tenon being the size of the square and the mould scribed to fit. When extra strength is required a dowel is used as well as the tenon. The one on the bottom side has a small tenon let into the square on the bar, and a piece haunched out between the tenon and rebate for glass to fit on the piece left on the other bar. This is known as franking, a good but costly joint.

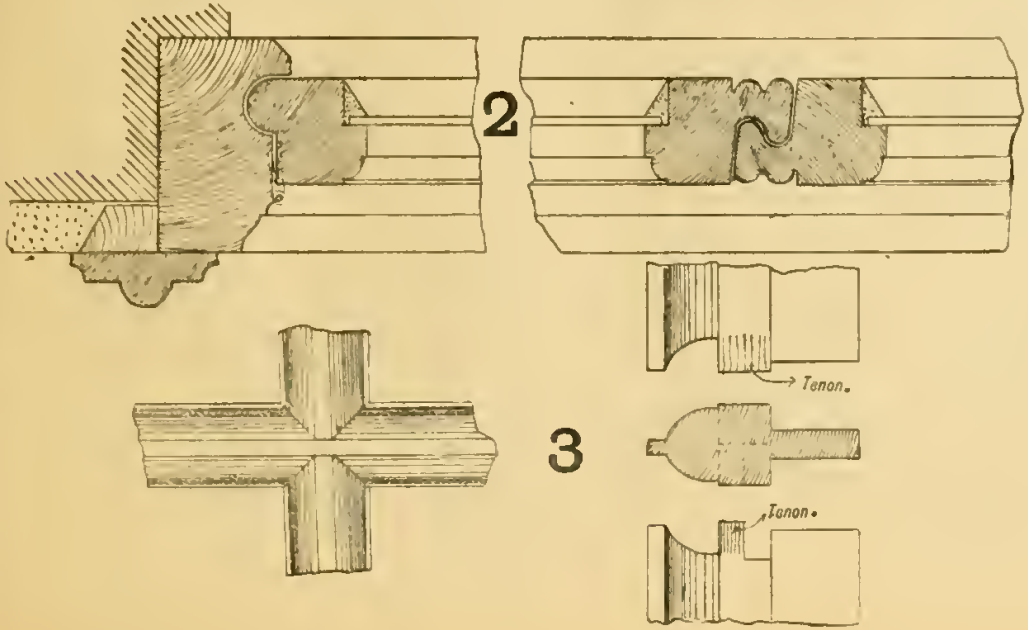
Fig. 4. Shows how to secure a circular frame, or a semi-circular head to the stiles, &c. These joints are held together by keys and wedges, that being the key with the large ends on, as seen in plan at b, or in elevation at a. Care must be taken that they are not too long, but allow the joints to bear on the shoulders. A loose key is used for the crown, and a solid key, worked on the jamb or stile, for the joint at the springing. This latter has a loose key sometimes.

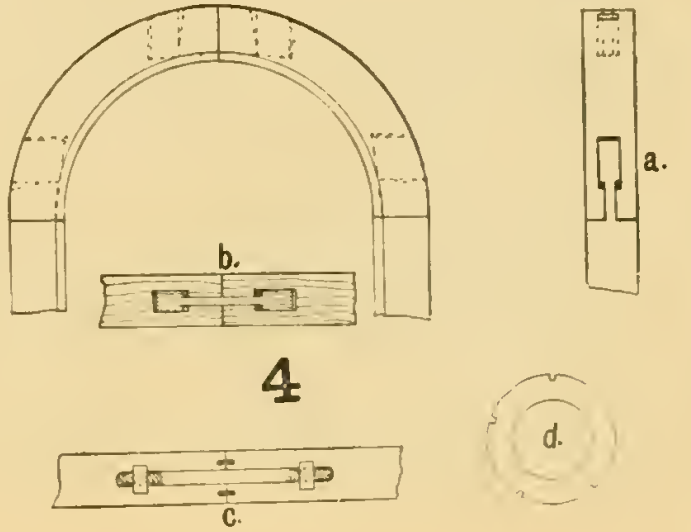
The above joints may be secured by a joint bolt as seen at c; this bolt has two nuts, one at each end, one being a common nut, and the other a circular one as seen in enlarged plan at d. This has notches in the edges and may be tightened up by an iron chisel known as a chaser. A washer must be used at this end to keep the nut from eating into the wood during the time it is being screwed up. The hole being bored in its proper place and to the right depth, the nuts are then let in from the top side. In order to keep the joint flush, cross tongues are used, one at each side of the bolt.



HORIZONTAL SECTION THROUGH A YORKSHIRE LIGHT.

SECTION AT A.B





SCARFED JOINTS.

This plate, with the exception of the last three figures, illustrates what are known as scarfed joints, *i.e.*, the timber requires to be lengthened. A few of the methods adopted in practice are shown.

Fig. 1. Shows at a and b a side elevation and plan, of a plain half-lapped joint for a wall plate.

Fig. 2. Shows at a and b a dovetail shape. The first is the one that is invariably carried out in practice, the length being about 6″.

Fig. 3. Shows a lapped joint where two beams are laid side by side, or edge to edge, and held by bolts or straps; a side elevation and section being shown. In all cases where bolts are used care must be taken to have good square washers, to prevent the head and nut coming in contact with the wood.

Fig. 4. Shows a fished joint, the beams butt end to end, and are secured by wooden pieces. The one at the top being let in, and the one at the bottom having keys to prevent one sliding over the other; the whole being held together by bolts.

Fig. 5. Shows a similar joint to the last, in this case the fish plates are not let into the beams; when this is the case, extra bolts must be put in as shown.

In rough temporary work a fish piece may be put on each of the four sides. The last three joints are clumsy, but strong.

Fig. 6. Shows a joint where the fishing pieces are of iron; this makes a neater joint than wood plates. The top plate may be let in, as seen, to keep it from sliding, but care must be taken that the pieces so let in fit tight, otherwise they weaken the beam, as that edge is taken to be in compression. The plate on the bottom side is not let in, as the fibres are stretched and must not be cut.

Fig. 7. Shows a scarfed joint to resist a cross-strain, the top side being left square, the bottom side being assisted by an iron plate.

Fig. 8. Shows a scarf often used as a joint to resist a tensile strain. This is the worst form of scarf that can be made and ought to be avoided; a very little strain will slide the piece off from a to b.

Fig. 9. Shows one to resist either tension or compression, and ought always to be used in preference to the last.

Fig. 10. Shows plan and side view of a joint to prevent the ends of the scarf from lipping, either sideways or up and down, the ends being bevelled as shown in plan and elevation.

Fig. 11. Shows two views, which explain how the same object may be obtained by having all corners square.

Figs. 10 and 11. Are ingenious and good, but their expense will prevent them from being much used.

Figs. 8, 9, 10 and 11. Have fox wedges to draw the heading joints together.

The methods of scarfing are innumerable, but a simple joint is to be preferred. The nature, &c., of your pieces to be scarfed, and the amount and direction of the pressure to be provided for must determine the scarf that will be most suitable.

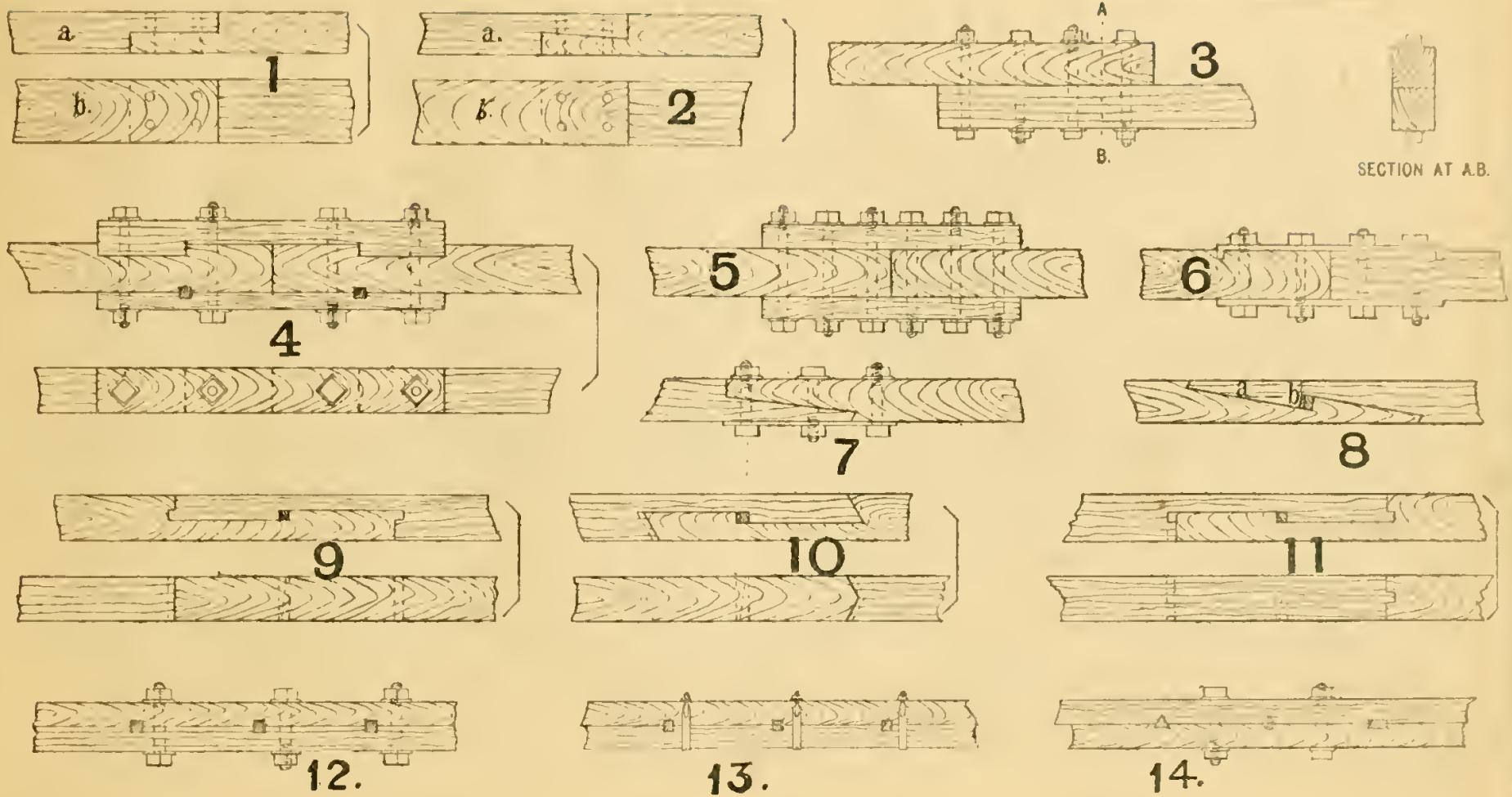
The remaining three figures show what are known as built-up beams, used for girders, &c.,

Fig. 12. Shows how pieces are put in to prevent the beams from sliding one over the other. The whole being held together by bolts, which are placed near the keys.

Fig. 13. Shows a similar method to the last, except that straps are used instead of bolts.

Fig. 14. Shows a triangular, circular, and double V piece to prevent sliding, the beams being held together by bolts; the bolts are in the centre between the hardwood pieces, and are not so effective as the last two.

The first two are English methods, and the last a French method.


a.
b.
1
a.
b.
2
A
B.
3
SECTION AT A.B.
4
5
6
7
a
b
8
9
10
11
12.
13.
14.

JOINTS IN ROOFS, &c.

Fig. 1. Shows a joint between a tie-beam and a principal rafter, having a sharp corner at a, where it should have a square abutment, a joint like this must be avoided.

Fig. 2. Can only be tolerated when the back is unavoidably near the end of the tie beam.

Fig. 3. On the left side of the king-post the joint runs underneath and is bad; one like that on the right side of the king-post ought to be preferred.

Fig. 4. Shows four joints, all bad and to be rejected.

Fig. 5. The strut on the left is correct, that on the other side of the king-post requires an undercut joint, which of course, is objectionable. The haunched joint at the foot of the king-post, and the forked joint Figs. 4 and 5 give the carpenter a good chance of scamping his work.

Figs. 6, 7, and 8. Show circular joints, bad in construction, and very expensive.

All the above joints except 7 are in roof trusses, the exception being a story post under a beam.

Figs. 9 to 17. Show how dados, lavatories, W. C's., &c., may be joined at the external angles. The last three are somewhat complicated and not often used. These joints may be strengthened by triangular blocks as seen in the corner, Fig. 9.

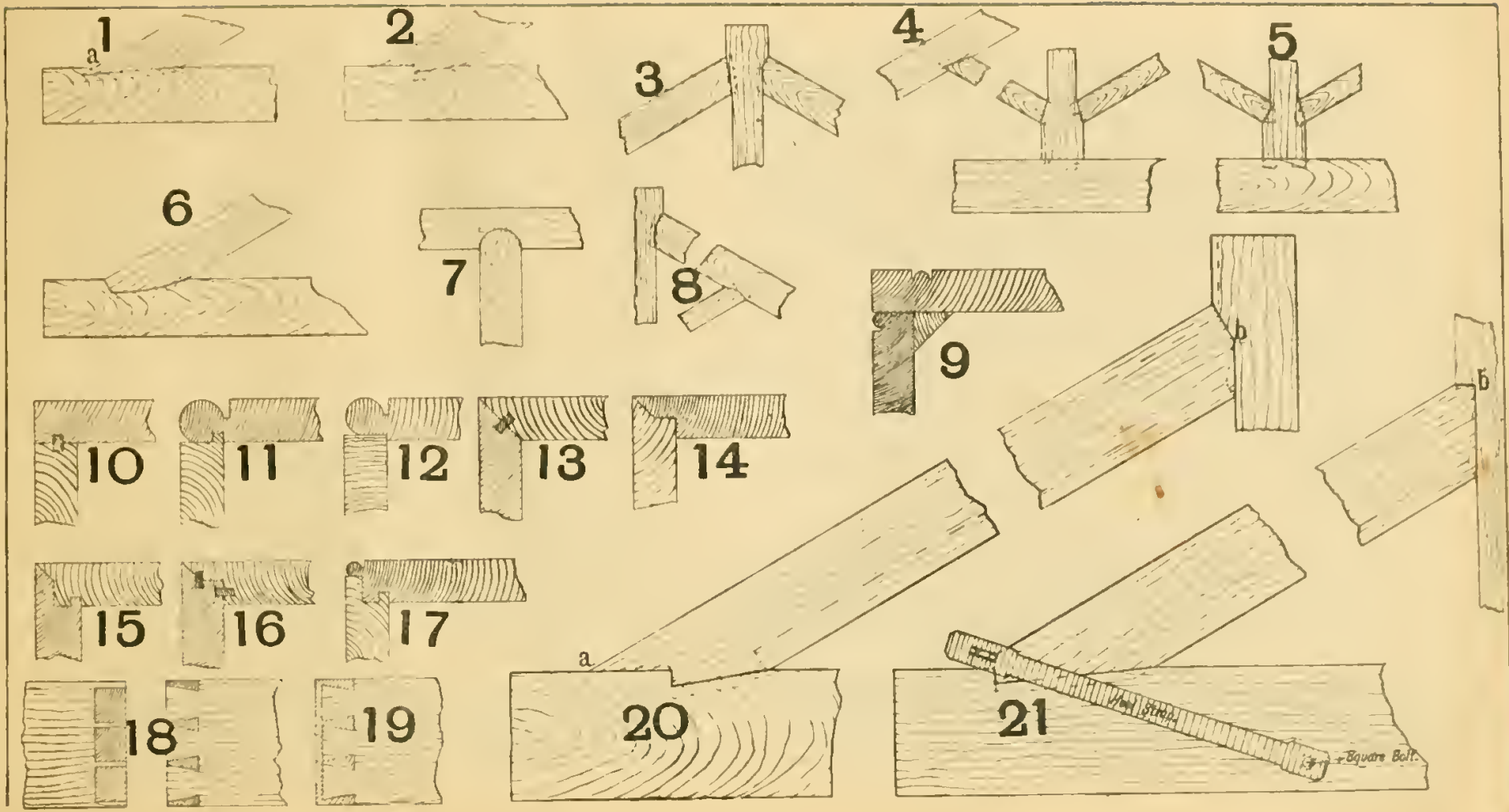
Fig. 11. By omitting the returned bead this becomes a good strong joint for internal angles such as skirting boards, as well as for dados, lavatories, W.C's., &c.

Fig. 18. Shows how two boards of equal thickness are dovetailed together, such as the corners of boxes, &c.

Fig. 19. Shows how two pieces are to be dovetailed together where it is desirable to keep the end or cross grain out of sight on one face, as a drawer front, &c., where the side is dovetailed as shown on the drawing.

Fig. 20. Shows an enlarged view of Fig. 2, the dotted lines show how the joints would be after the timber has shrunk, or dried, the whole of the weight would be thrown on the sharp point a. At the top end, though the end of the back is cut square, the king-post or queen-post must be bevelled as shown, hence a sharp angle is formed at b.

Fig. 21. Has a heel strap with gibs and cotters, the bolt through the beam is square, this should be used when a sufficient length of the tie-beam end cannot be left on to resist the pressure, length must not be gained by cutting back as shown at Fig. 20. At the head of the rafter the king-post is cut in square, this prevents the rafter from rising up, but when the timber has become dry then a bad joint is the result as seen by the dotted lines from b. In cutting or forming joints for roof trusses let them be as near a right angle as possible.


1
a
2
3
4
5
6
7
8
9
b
10
11
12
13
14
15
16
17
18
19
a
20
21
Square Bolt

ARITHMETIC.

In order that a student may thoroughly grasp the meaning, and understand the principle of determining results by figures, he should be conversant with the following somewhat elementary principles in arithmetic. For instance, in such as determining the length of a line; when the base and perpendicular are given to determine the hypothenuse; or given the hypothenuse and base, to determine the perpendicular, &c. Given the sides of a square, or the sides of a rectangle, triangle, &c., to determine the area, and a second one similar to the given one, but double the area. Given the diameter of a circle, to determine its area, and a second one double the area of the first, &c. Given two concentric circles to determine the area between them.

Questions similar to these may easily be solved if the student has a little knowledge of mensuration, square and cube root, &c.

One or two examples are worked out to show the application of this important subject to the Building trade.

The square root of a number is that number which when multiplied by itself will equal the given number, and is usually expressed by the symbol $\sqrt{\ }$.

The cube root of a number is that number which when multiplied by itself three times will equal the given number, and is usually expressed by this symbol $\sqrt[3]{\ }$. The cube root of 27 is 3. Proof $3 \times 3 \times 3 = 27$.

Exercise 1. Let it be required to find the square root of 529.

```
  529 ( 23 Ans.
  4
 ----
43) 129
    129
    ---
    ...
```

1. Divide the given number into periods of two figures each, pointing from right to left. If decimals occur, then point from left to right, beginning at the decimal point. In the example put a dash two figures from the right hand end, which is between the 2 and 5.

2. Find the greatest square number in the left-hand figure or figures, place its root (2) on the right. 3. Subtract this square number from the first period (5) and to the remainder annex the next period for a dividend. 4. Double the figure (2) of the root found for a divisor; find how often it is contained in the dividend, omitting the right hand figure, and annex the quotient both to the root and to the divisor. The first 2 when doubled = 4, and 3 the new quotient; then 43, which is the complete divisor; multiply 43 by 3 = 129, which gives no remainder.

Exercise 2. To find the square root of a fraction, say $\sqrt{\frac{5}{7}}$.

```
7 ) 5·0 ( ·714285          ·714285 ( ·845 Ans.
    49                     64
    ---                    ---
     10                164 ) 742
      7                      656
     ---                    ----
      30               1685 ) 8685
      28                      8425
      ---                     ----
       20                      260
       14
       ---
        60
        56
        ---
         40
         35
         ---
          5
```

Reduce the fraction to a decimal by dividing the numerator by the denominator (as shown), and then find the square root of the result.

Exercise 3. Find the cube root of a given number.

```
                    45499293 ( 357 Ans.
              3³=27
          ---------------
   30² × 3=2700 | 18499
 30 × 5 × 3= 450 |
        5²=  25 |
          ------ |
           3175 | 15875
          ------ |
350² × 3=367500 | 2624293
350 × 7 × 3=  7350 |
        7²=    49 |
          ------ |
          374899 | 2624293
                 ..........
```

Take any three figures as 357 and raise them to the third power which equals 45499293, and prove that the cube root is 357.

To extract the cube root. 1. Divide the given number into periods of three figures as shown by the dashes beginning at the right-hand end. 2. Find the greatest cube number in the first period (45), and place its root on the right as the first figure. 3. Subtract this cube number from the first period, and to the remainder 18 annex the second period 499=18499. 4. Place the first figure found (3) in the front and add a cipher making this 30, then square this and multiply it by 3 which in this case = 2700. This number is the trial divisor, see how often this will go in the 18499, in this it will be found to be 5. 5. Then multiply the $30 \times 5 \times 3 = 450$, place this under the trial divisor. 6. Square the last figure

found (5^2) = 25, this result is to be added to the two lines above, which gives (3175) the complete divisor. Having multiplied this by the 5, subtract from the above, and to the remainder annex the next period, thus 2624293. 6. To the 35 add a cipher 350, square this and multiply it by 3 which equals 367500. This is the trial divisor, in this it will give 7, next multiply 350 by this last root figure found, and this by 3. Thus $350 \times 7 \times 3 = 7350$, which place under the trial divisor. 7. Square the last root figure found (7), add this product to the two lines above, which equals 374899, this being the complete divisor, with which proceed as before.

Exercise 4. To find the cube root of a mixed number, that is one containing decimals as 583·216974.

583·216974 (8·35 Ans.

$8^3 = 512$

$80^2 \times 3 =$	19200	71216
$80 \times 3^2 \times 3 =$	720	
$3^3 =$	9	
	19929	59787
$830^2 \times 3 =$	2066700	11429974
$830 \times 5 \times 3 =$	12450	
$5^2 =$	25	
	2079175	10395875
		1034099

To find this cube root proceed as above until the end of the whole number, put decimal point at the end of the root, and continue as before.

To find the cube root of a fraction reduce it to a decimal, and proceed as in Exercise 4.

Instead of having to determine the square and cube root one time after another, a table of these roots for the following numbers is given.

No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.
0·25″	·5000	·6300	2·75″	1·6583	1·4010
0·5″	·7071	·7937	3″	1·7321	1·4422
0·75″	·8660	·9086	3·25″	1·8028	1·4812
1″	1·0000	1·0000	3·5″	1·8708	1·5183
1·25″	1·1180	1·0772	3·75″	1·9365	1·5536
1·5″	1·2247	1·1447	4″	2·0000	1·5874
1·75″	1·3229	1·2051	5″	2·2361	1·7100
2″	1·4142	1·2599	6″	2·4495	1·8171
2·25″	1·5000	1·3104	7″	2·6458	1·9129
2·5″	1·5811	1·3572	8″	2·8284	2·0000

When the two sides of a right-angled triangle are known, the hypothenuse may be found by squaring the sides and extracting the square root of the sum. When the hypothenuse and one side are given the third side may be found as follows: from the square of the former subtract the square of the latter and extract the square root of the difference.

Exercise 5. Determine the area of a square room, 12′ 3″ × 12′ 3″. Before multiplying, reduce the inches to the decimal of a foot, 12′ 3″ = $12\frac{3}{12}$ = $12\frac{1}{4}$ = 12·25. Area = 12·25 × 12·25 = 150·0625 square feet.

Exercise 6. If the room given in the last question has to be boarded, what would be the nett area of boarding after deducting the hearth-flag which is 4′ 6″ × 1′ 6″?

Area of hearth-flag 4′ 6″ × 1′ 6″ = 4·5 × 1·5 = 6·75 square feet.

Nett area = 150·0625 — 6·75 = 143·3125 square feet.

Exercise 7. A room is in the form of a rectangle 18′ 3″ × 12′ 8½″. What is its area, and the length of the sides of a similar room double the area of the first? What is the area of the flooring for the second room, allowing for an isosceles triangle in one corner, the sides of the triangle measured along each wall being 5′?

First method by duodecimals:

12′	8″	6‴
18′	3″	0‴
228′	9″	0‴
3′	2″	1‴ 6⁗
231′	11″	1‴ 6⁗

Note the term in the second column must be multiplied by 12 to bring it into square inches.

= 231 sq. ft. 133½ sq. ins.

Second method by fractions:

Area = 18′ 3″ × 12′ 8½″ = $18\frac{1}{4} \times 12\frac{17}{24} = \frac{73}{4} \times \frac{305}{24} = \frac{22265}{96} = 231\frac{89}{96}$ sq. ft. = 231 sq. ft., 133½ sq. ins. Length of sides containing double the area of the first, Long side = 18′ 3″ × $\sqrt{2}$ = 18·25 × 1·4142 = 25·80915 ft. = 25′ 9·7″. Short side = 12′ 8½″ × $\sqrt{2}$ = 12·7083 × 1·4142 = 17·972 ft. = 17′ 11·7″, therefore sides of second room are respectively, 25′ 9·7″ and 17′ 11·7″.

Area of the triangle = 5 × 5 ÷ 2 = 12½ sq. ft. = 12 sq. ft. 72 sq. ins. Nett area of flooring after deducting hearth = 231 sq. ft. 133½ sq. ins. + 231 sq. ft. 133½ sq. ins. — 12 sq ft. 72 sq. ins. = 463 sq ft. 123 sq. ins. — 12 sq. ft. 72 sq. ins. = 451 sq. ft., 51 sq. ins.

AREAS OF PLANE FIGURES, &c.

The following is a list of the ordinary plane figures that a carpenter and joiner has to deal with:— (See small block at the bottom.)

Ex. 1. To find the area of a triangle when the base a b and the perpendicular c d are given. Rule.—*Multiply the base by the perpendicular height, half the product will be the area.*

In Fig. 1, let a b = 9′, and c d = 5·125′, find the area.

Area = 9 × 5·125 ÷ 2 = 23·0625 superficial feet.

Ex. 2. To find the perpendicular when the base and area are given.

Rule.—*Divide twice the area by the base, and the result will be the perpendicular. If the perpendicular and area be given, divide twice the area by the perpendicular, and the result will be the base.*

When the base a b is 9′, and the area 23 0625′.

Area × 2 = 46·1250′. 46 1250 ÷ 9 = 5·125′ perpendicular.

Ex. 3. Find the base, when the perpendicular c d = 5·125′.

Area × 2 = 46·1250′. 46·1250 ÷ 5·125 = 9′. The base a b is 9′.

Ex. 4. What is the area of the triangle a b c. a b 9′; a c 6′; b c 8′?

Rule.—*From half the sum of the three sides subtract each side separately; multiply the half sum and the three remainders together, and the square root of the product will be the area.* See rules for determining square and cube root.

The sum of the three sides = 23; 23 ÷ 2 = 11½; 11½ − 9 = 2½; 11½ − 8 = 3½; 11½ − 6 = 5½; 11½ × 5½ × 3½ × 2½ = 553·4375′.

$\sqrt{553{\cdot}4375}$ = 23·52 superficial feet.

Ex. 5. What would be the length of base of a triangle similar to Fig. 1, to contain double the area?

Length of given base is 9′; length of required base = $\sqrt{9^2 + 9^2}$; = $\sqrt{81 + 81}$ = $\sqrt{162}$ = 12·727′.

Ex. 6. To find the side of a square to contain double the area of a square 5′ side.

Area of given square = 5 × 5 = 25 superficial feet. Side of required square = $\sqrt{25 + 25}$ = $\sqrt{50}$ = 7·071′. *See other method of working a similar problem, Page 55; Ex. 7.*

To find the area of a square, a rectangle, a rhombus, and a rhomboid.

Rule.—*Multiply the length by the perpendicular breadth, and the product will be the area.* For the rhombus, the product of the two diagonals divided by 2 will give the area.

Ex. 7. The plan of a school is in the form of a rectangle, 30′ × 20′. What would be the size of a similar one double the area?

Length of the required long side = $\sqrt{30^2 + 30^2}$ = $\sqrt{900 + 900}$ = $\sqrt{1800}$ = 42·426′.

Length of the required short side = $\sqrt{20^2 + 20^2}$ = $\sqrt{400 + 400}$ = $\sqrt{800}$ = 28·284′. *See other methods of working a similar example.*

To find the area of a circle. *Multiply the square of the diameter by* ·7854.

To find the circumference when the diameter is given. *Multiply the diameter by* 3·1416.

To find the diameter when the circumference is given. *Divide the circumference by* 3·1416.

Ex. 8. The diameter of a circle is 2·5′; what is the area?

Area = 2·5 × 2·5 × ·7854 = 6·25 × ·7854 = 4·90375 feet.

Ex. 9. What is the circumference of the last circle?

Circumference = 2·5 × 3·1416 = 7·854 feet.

Ex 10. If the circumference be 7·854 show that the diameter is 2·5′

Diameter = 7 854 ÷ 3·1416 = 2·5 feet.

To find the length of an arc of a circle as a c b Fig. 9.

Rule.—*From eight times the chord of half the arc subtract the chord of the whole arc; ⅓ of the remainder will be the approximate length of the arc.*

To find the chord of half the arc, as a c; *add together the squares of half the chord of the arc and of the height of the segment, and extract the square root of the product for the length of the chord of half the arc.*

Ex. 11. To find the length (a c) of the chord of half the arc of the segment, Fig. 9. Let a b = 16′ and c d 3′.

Length of a c = $\sqrt{a\,d^2 + c\,d^2}$; $\sqrt{64 + 9} = 8.514$ feet.

Ex. 12. Find the length of the arc a c b, in the last example.

Length of arc = 8·514 × 8 - (the chord) 16 ÷ 3 ; 68 352 16 = 52 352 ; 52·352 ÷ 3 = 17·451 feet.

Ex. 13. Find the length of the radius, Ex. 11.

Rule.—*Divide the square of half the chord by the height of the segment, the product will be the distance d e (Fig. 9), then the given height and this added together will be the diameter of the circle; and its half the radius.*

Chord of given arc, 16′; rise, 3′. $8^2 = 64$; 64 ÷ 3 = 21·33 ; diameter = 21·33 + 3 = 24·333, half of this is the radius = 12′ 2″ = e f or e h, Fig. 10.

The above is used to determine the length of radius for segmental arches when the opening and rise are given.

Ex. 14. Find the area of the sector f e h i, Fig. 10.

The same dimensions may be taken for this as in the last example.

Rule.—*Multiply the length of the arc by the radius; half the product is the area.*

Length of arc is 17 451 feet. Area of sector = 17·451 × by radius 12·166 ÷ 2 = 106·15 super. feet nearly.

To find the area of the segment, deduct the area of the triangle f e h from the area of the sector.

Area of triangle = 16 × by height of triangle 9·166 ÷ 2 = 73·33 feet.

Area of segment = 106·15 - 73·33 = 32·82 superficial feet.

Ex. 15. To find the area of the ring Fig. 11, i.e., the space contained between the two concentric circles.

Rule.—*Find the area of each circle; the difference is the area.*

Let the diameters be 6″ and 4½″ respectively. Area of large circle = 6 × 6 × ·7854 = 36 × ·7851 = 28·2744 sq. inches.

Area of small circle = 4·5 × 4·5 × ·7854 = 20·25 × ·7854 = 15·9043.

Required area = 28·2744 - 15·9043 = 12·37 superficial inches.

To find the area of an Ellipse.

Rule.—*Multiply the product of the two axes by ·7854.*

Ex. 16. Let a b Fig. 12 be 12′, and c d 6′. Find the area.

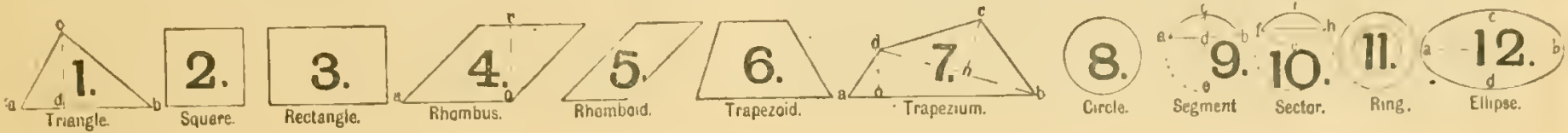
Area = 12 × 6 × ·7851 ; 72 × ·7854 = 56·5488 superficial feet.

To find the area of a Trapezoid. *Multiply the sum of the parallel sides by the perpendicular distance between them, and half the product will be the area.*

To find the area of a Trapezium, *make it into two triangles by the line* b d, *then find the area of the triangles* a b d *and* b c d, *and add them together.*

Ex. 17. What is the superficial area of a square of glass $24\frac{1}{16}'' \times 18\frac{1}{8}''$

Area = 385 ÷ 16 × 147 ÷ 8 = 442·148. This divided by 144 = 3·07 superficial feet.



APPLIED MENSURATION.

Exercise 1. What is the length of spare for a common roof, the distance across from point to point being 14′, and the rise 5′ 6″ ?

Required length $= \sqrt{(7^2 + 5{\cdot}5^2)} = \sqrt{(49 + 30{\cdot}25)} = \sqrt{79{\cdot}25} = 8{\cdot}9022$ ft.

Exercise 2. The length of spar is 15′, and half the width of the building 12′. What is the rise?

Rise $= \sqrt{(15^2 - 12^2)} = \sqrt{(225 - 144)} = \sqrt{81} = 9$ ft.

Exercise 3. If a roof 20′ long similar to Ex. 1 has to be boarded, (a) What is the area of the boarding for one side after deducting an opening made by a vertical square trunk 2′ 6″ side, passing through the roof, when two of its sides are parallel to the eaves and ridge? (b) When a diagonal is parallel to the ridge?

Area of roof before cutting $= 8{\cdot}9022 \times 20 = 178{\cdot}045$ sq. ft. To find the sides of opening, 7 : 8·9022 : : 2·5 : side; side $= 3{\cdot}1794$ ft. Area of opening $= 3{\cdot}1794 \times 2\ 5 = 7{\cdot}9485$ eq. ft. Required area $= 178{\cdot}046 - 7{\cdot}9485 = 170{\cdot}097$ sq.ft.

Second, when a diagonal is parallel to the ridge, the shorter diagonal of opening is equal to the diagonal of the square trunk, $= \sqrt{(2\frac{1}{2})^2 + (2\frac{1}{2})^2} = \sqrt{\frac{50}{4}} = \sqrt{12{\cdot}5} = 3{\cdot}5355$ ft.

To find longer diagonal, 7 : 8·9022 : : 3·5355 : longer diagonal. Longer diagonal $= 4{\cdot}4962$ ft. Area of opening $= \frac{3{\cdot}5355 \times 4{\cdot}4962}{2} = 7{\cdot}948$ sq. ft.

This proves that the openings are equal, the turning the trunk with a diagonal parallel to the ridge does not alter the size of the aperture.

Exercise 4. Let the same roof be pierced by a vertical circular shaft. Determine the area of the aperture, the diameter of the shaft being 2′ 6″. To determine the area of an ellipse multiply the two diameters together, and multiply the result by ·7854. The elliptical opening will have one diameter 2′ 6″. The longer diameter is found the same as the long diagonal in the last question, and $= 3{\cdot}1794$. Area of ellipse $= (3{\cdot}1794 \times 2{\cdot}5) \times {\cdot}7854 = 7{\cdot}9485 \times {\cdot}7854 = 6{\cdot}2427$ sq. ft.

Exercise 5. A square building 20′ side, is to be covered with a hipped roof, the sides are all equally inclined at $27\frac{1}{2}°$, and meet in a point. Determine the length of a hip.

First find the distance from the eaves to the apex (see table) $= 10 \times 1{\cdot}1274 = 11{\cdot}274$ ft. Length of hip equals the hypothenuse of a right angled triangle sides 10 ft. and 11·274 ft. Length of hip $= \sqrt{(10^2 + 11{\cdot}274^2)} = \sqrt{(100 + 127{\cdot}103)} = \sqrt{227{\cdot}103} = 15{\cdot}07$ ft.

To find the cubical content of a rectangular solid. *Multiply the length, breadth, and thickness together.*

Ex. 6. What is the cubical content of 100 common rafters, each 15′ $2\frac{1}{2}$″ long, $3\frac{9}{16}$″ deep and $2\frac{1}{4}$″ broad?

Cubical content of one rafter $= 182\frac{1}{2} \times 3\frac{9}{16} \times 2\frac{1}{4} \div 1728 = \frac{365}{2} \times \frac{57}{16} \times \frac{9}{4} \times \frac{1}{1728} = \frac{365 \times 19}{128 \times 64} = \frac{6935}{8192}$ Required content $= \frac{6935 \times 100}{8192} = 84{\cdot}65$ cu. ft.

Ex. 7. A Tank is in the form of a hollow cylinder, 3′ diameter, 6′ 6″ deep. How many gallons of water will it hold? Note.—There are 277·274 cubic inches in a gallon.

Cubical content $= 3^2 \times {\cdot}7854 \times 6\frac{1}{2} = \frac{9 \times {\cdot}7854 \times 13}{2} = 45{\cdot}946$ cu. ft.

Required number of gallons $= \frac{45{\cdot}946 \times 1728}{277{\cdot}274} = 286{\cdot}34$.

Ex. 8. A water cistern is in the form of a rectangle, 4′ 6″ long, 3′ 3″ wide and 2′ 8″ deep. How many gallons will it hold, and what will be the weight of the water when full?

Volume of cistern $= 64 \times 39 \times 32 = 67392$ cubic inches.

Required number of gallons $= \frac{67392}{277{\cdot}274} = 243{\cdot}05$.

Weight $= \frac{67392}{1728} \times 62\frac{1}{2} = 2437{\cdot}5$ lbs.

Note.—A cubic foot of water weighs $62\frac{1}{2}$ lbs.

FLOOR TIMBERS.

The following rules are given by Tredgold for determining the sizes of FLOOR TIMBERS:

L = Length in feet. B = Breadth in inches. D = Depth in inches.

Bridging or Common Joists (12″ from centre to centre) the timber to be of fir. $D = \sqrt[3]{\frac{L^2}{B}} \times 2{\cdot}2$. Trimmer joists should be calculated by the same rules as binders. Trimming joists, to the width of common joists add $\frac{1}{8}$ of an inch for every joist carried by the trimmer.

Binding Joists (6 feet apart) $D = \sqrt[3]{\frac{L^2}{B}} \times 3{\cdot}42$. $B = \frac{L^2}{D^3} \times 40$.

Girders. $D = \sqrt[3]{\frac{L^2}{B}} \times 4{\cdot}2$. $B = \frac{L^2}{D^3} \times 74$.

Ceiling Joists. $D = \frac{L}{\sqrt[3]{B}} \times 0{\cdot}64$. These to be 2″ thick and 12″ centre to centre.

Use the formulæ and work an example in each.

Ex. 1.—Determine the depth of a **Common Joist** length 14′, and the breadth 3″.

$D = \sqrt[3]{\frac{L^2}{B}} \times 2{\cdot}2 = \sqrt[3]{\frac{14^2}{3}} \times 2{\cdot}2 = \sqrt[3]{\frac{196}{3}} \times 2{\cdot}2 = \sqrt[3]{65{\cdot}33} \times 2{\cdot}2 = 4{\cdot}03 \times 2{\cdot}2 = 8{\cdot}86''$. *In practice this would be made* 9″.

Ex. 2.—Determine the depth of a **Binding Joist**, length 14′, breadth 8″.

$D = \sqrt[3]{\frac{196}{8}} \times 3{\cdot}42 = \sqrt[3]{24{\cdot}5} \times 3{\cdot}42 = 2{\cdot}904 \times 3{\cdot}42 = 9{\cdot}93$, say 10″.

Ex. 3.—Determine the breadth of the above **Binder.**

$B = \frac{196}{1000} \times 40 = {\cdot}196 \times 40 = 7{\cdot}84''$. *This would be* 8″.

Ex. 4.—Determine the depth of a **Girder,** 20′ long and 9″ broad.

$D = \sqrt[3]{\frac{20^2}{9}} \times 4{\cdot}2 = \sqrt[3]{\frac{400}{9}} \times 4{\cdot}2 = \sqrt[3]{44{\cdot}44} \times 4{\cdot}2 = 3{\cdot}54 \times 4{\cdot}2 = 14{\cdot}87''$.

Ex. 5.—Determine the breadth of the above **Girder.**

$B = \frac{20^2}{15^3} \times 74 = \frac{400}{3375} \times 74 = {\cdot}1185 \times 74 = 8{\cdot}769''$. *This would be* 9″.

Ex. 6.—Determine the depth of a **Ceiling Joist,** length 7′, breadth 2″.

$D = \frac{L}{\sqrt[3]{B}} \times 0{\cdot}64 = \frac{7}{\sqrt[3]{2}} \times 0{\cdot}64 = \frac{7}{1{\cdot}2599} \times 0{\cdot}64 = 5{\cdot}556 \times 0{\cdot}64 = 3{\cdot}55''$.

NOTE.—In working out the above examples, the formulæ were repeated for the first and last examples.

The constants for deflection are from Professor Barlow's rules.

Deflection as defined by Professor Barlow—

When a beam or joist is supported at each end, the distance to which the middle is forced down below its original position by the load is termed its deflection

The deflection varies as the cube of the length The stiffness varies as the cube of the depth multiplied by the breadth and divided by the cube of the length.

Constants for Deflection.	
Teak	5538
English Oak	8399
Ash.....	8807
Pitch Pine..	2837
Red Pine ..	4259
Riga Fir ..	3079
*Memel Deal	4509

*This is from Tredgold's.

It is generally understood that a beam, joist, &c., should not deflect more than $\frac{1}{288}$ of the length, or $\frac{1}{40}$ of an inch to the foot.

Ex. 7.—Let it be required to find the deflection of the joist given in Ex. 1. d′ equals the deflection = the cube of the length in feet × by weight on the centre of the joist in lbs. ÷ by breadth in inches × by the depth in inches cubed × by constant. B breadth in inches; D depth in inches; L length in feet; C constant; W = weight in lbs. on the centre.

$d' = \frac{L^3 \times W \text{ in lbs.}}{B \times D^3 \times C} = \frac{2744 \times 1176}{3 \times 729 \times 4259} = {\cdot}34''$ or a fraction less than $\frac{3}{8}''$

$C = \frac{L^3 \times W \text{ in lbs.}}{B \times D^3 \times d'}$. $B = \frac{L^3 \times W \text{ in lbs.}}{d' \times D^3 \times C}$. $D = \sqrt[3]{\frac{L^3 \times W \text{ in lbs.}}{d' \times B \times C}}$

Ex. 8.—Determine the deflection of a beam of red pine, L 20′, D 12″, B 8″, W 2680 lbs.

$d' = \frac{20^3 \times 2680}{8 \times 12^3 \times 4259} = \frac{8000 \times 2680}{8 \times 1728 \times 4259} = {\cdot}364''$, about $\frac{3}{8}''$

It will be seen from this that one-tenth of the breaking weight is as much as should be put upon a long beam.

Ex. 9.—Determine the depth of a beam similar to Ex. 8. L 20′. B 8″. W 2680 lbs. d′ $\frac{1}{40}''$ to a foot = ·5″

$D = \sqrt[3]{\frac{8000 \times 2680}{{\cdot}5 \times 8 \times 4259}} = \sqrt[3]{\frac{1000 \times 2680 \times 2}{4259}} = \sqrt[3]{\frac{5360000}{4259}} = \sqrt[3]{1258{\cdot}51} = 10{\cdot}80''$

Ex. 10.—Determine the breadth of the above beam, L 20′, D 12″, d′ $\frac{1}{40}''$ to one foot. W 2680 lbs. C 4259.

$B = \frac{20^3 \times 2680}{{\cdot}5 \times 12^3 \times 4259} = \frac{8000 \times 2680}{864 \times 4259} = \frac{670000}{114903} = 5{\cdot}83''$.

SIZE OF ROOF TIMBERS.

Before commencing to determine the sizes of various members in a roof truss, it is advisable that the lengths of each piece should be clearly defined.

Let it be required to find the lengths of a c; d e, and c f.

Fig. 1. Let a b equal 20′, and the pitch 30°. Length of principal rafter a c = a f × by (the number in the column) 1·1547 = 10 × 1·1547 = 11·547 feet.

Length of king post c f = a f × by the number in the column = 10 × 0·5774 = 5·77 feet.

Length of strut d e. *Note.*—e *is taken 6″ above the tie beam.*

To determine the length of d e, the king post may be taken as the base, and the length found in the same way as the principal rafter. Thus, length of c e = 5·27 feet. 5·27 ÷ 2 = 2·635 feet. Multiply this by the number in the column opposite 60°. 2·635 × 2·000 = 5·27 feet. In this example, *i.e.*, when the angles are 60°, the length of the strut d e is equal to c e.

Fig. 2. Determine the length of rafter m o, strut p q, and queen n o. Span 45′, pitch 27½°, queens 15′ centre to centre. Length of rafter m o = m n × by 1·1274 (this number is taken from the column opposite 27½°). m o = 15 × 1·1274 = 16 911 feet.

Length of queen n o = m n × ·5206 = 15 × ·5206 = 7·809 feet.

Length of strut p q, this may be found similar to the strut for Fig. 1; or, find the length of base q r, and treat it as a rafter.

To find the new base q r. If the base m n of the right angle triangle be 15′, and the perpendicular n o be 7·809′, what length will the base of a similar triangle be, when the perpendicular q o is 7·309′?

As 7·809′ : 15′ : : 7·309′ : q r, the new base.

q r = 15′ × 7·309′ ÷ 7·809′ = 14·0394′; q s = 14·0394′ ÷ 2 = 7·0197′; p q = q s × 1·1274 = 7·914′. *Note,* q *is 6″ above the tie beam.*

When the strut and rafter are at the same inclination the length of strut is equal to half the principal rafter after deducting the length m r *taken off by shortening the base.*

This may be stated as follows:—If the base m n of the right angled triangle be 15′, and the hypothenuse m o 16·911′, what length will the hypothennse be when the base q r is 14·0394?

As 15′ : 16·911′ : : 14·0394′ : o r; o r = 16·911′ × 14 0394′ ÷ 15′ = 15·82′; p q = 15·82′ ÷ 2 = 7·91′.

The following are the rules given by Tredgold for determining the sizes of roof timbers:—

The pitch may be taken at 30°, the timber of red deal, and the covering of slate.

B = Breadth in inches. D = Depth in inches. A = Area of section of piece in inches = B × D. L = Length of piece in feet. S = Span of roof in feet. Tie beam.—u = Length of longest unsupported part in feet.

When the tie beam has to support a ceiling only.
When there are rooms the tie beam must be calculated as a girder.

Tie beam.—$D = \frac{u}{\sqrt[3]{B}} \times 1{\cdot}47$.

King post.—A = L × S × 0·12.

King Bolt.—Diameter in inches = $\sqrt{S} \times 0{\cdot}2$.

Queen post.—t = Length in feet of part of tie-beam suspended by queen-post. A = L × t × 0·27.

Queen bolt.—Diameter in inches = $\sqrt{t} \times 0{\cdot}29$.

Struts and Braces.—r = Length in feet of part of principal rafter supported by the strut. $D = \sqrt{L \times \sqrt{r}} \times 0{\cdot}8$. $B = \frac{6}{10} D$.

Principal Rafters.—Supported by struts over which the purlins rest.

In King-post roof.—$D = \frac{L^2 \times S}{B^3} \times {\cdot}096$

In Queen-post roof.—$D = \frac{L^2 \times S}{B^3} \times 0{\cdot}155$.

} The thickness is generally the same as that of the tie beam and king or queen post.

Purlins.—C = Distance in feet that the purlins are apart.

$D = \sqrt[4]{L^3 \times C} \times 1{\cdot}0$ $B = \frac{6}{10} D$.

Common rafters.—$D = \frac{L}{\sqrt[3]{B}} \times 0{\cdot}72$.

Straining beam.—$D = \sqrt{L \times \sqrt{S}} \times 0{\cdot}9$. Breadth and depth to be as 7 to 10.

Common rafters should not be more than 8′ bearings, this would determine the number of purlins, and a strut should be placed immediately under each purlin. From this it will be seen that the maximum span for a king-post truss is 30 feet. For a queen-post truss 45 feet span would be the limit.

For weight on a superficial foot of roof, allow 60 lbs. This is for weight of slates, wind, &c.

Use the given rules and determine the following:—

Ex. 1. Find the depth of tie beam for a king-post truss, span 20 feet. Let the breadth be 4". $D = \frac{10}{\sqrt[3]{4}} \times 1{\cdot}47 = \frac{10}{1{\cdot}5874} \times 1{\cdot}47 = 6{\cdot}3 \times 1{\cdot}47 = 9{\cdot}261$". This may be made $9\frac{1}{4}$".

Ex. 2. Find the area of the king-post, Fig. 1. $A = 6{\cdot}77 \times 20 \times 0{\cdot}12 = 115{\cdot}4 \times 0{\cdot}12 = 13{\cdot}848$ square inches. Let the thickness be 4", then the breadth will be $13{\cdot}848 \div 4 = 3{\cdot}462$ inches. This may be made $3\frac{1}{2}$".

Ex. 3. Find the sectional area of the queen-post, Fig. 2.

$A = 7{\cdot}809' \times 15 \times 0{\cdot}27 = 31{\cdot}626$ square inches. Let the depth be 6", then the breadth $= 31{\cdot}626 \div 6 = 5{\cdot}254$". In this the queen would be $6" \times 5\frac{1}{4}$".

Ex. 4. Find depth of strut, for length see Fig. 1.

$D = \sqrt{5{\cdot}27 \times \sqrt{5{\cdot}77}} \times 0{\cdot}8 = \sqrt{5{\cdot}27 \times 2{\cdot}4} \times 0{\cdot}8 = \sqrt{12{\cdot}648} \times 0{\cdot}8 = 3{\cdot}5 \times 0{\cdot}8 = 2{\cdot}84$"

This would be $4" \times 3"$.

Ex. 5. Find depth of principal rafter in Fig. 1. The breadth may be 4". $D = \frac{11{\cdot}547^2 \times 20}{64} \times {\cdot}096 = \frac{2666{\cdot}6}{64} \times {\cdot}096 = 41{\cdot}66 \times {\cdot}096 = 3{\cdot}999$, this would be 4".

Ex. 6. Find D for principal rafter in Fig. 2. $B = 6"$.

$D = \frac{16{\cdot}911^2 \times 45}{216} \times 0{\cdot}155 = \frac{285{\cdot}9819}{216} \times 0{\cdot}155 = 59{\cdot}57 \times 0{\cdot}155 = 9{\cdot}23"$.

This is an exceptionally long rafter, and in many cases the length would not exceed 15', and the depth of principal rafter would be about $7\frac{1}{2}$".

Ex. 7. Find depth of purlin when $L = 10$; $C = 7$.

$= \sqrt[4]{10^3 \times 7} \times 1{\cdot}0 = \sqrt[4]{7000} \times 1{\cdot}0 = 9{\cdot}14"$.

$B = \frac{6}{10} D = 9{\cdot}14 \times \frac{6}{10} = 5{\cdot}48"$. This may be $9" \times 5\frac{1}{2}$".

Note.— $\sqrt[4]{\ }$ means that the square root has to be extracted twice, i.e., the square root of 7000 is taken, and then the square root of the result again; thus $\sqrt{7000} = 83{\cdot}66$. $\sqrt{83{\cdot}66} = 9{\cdot}14$".

Ex. 8. Find the depth of a spar or common rafter. $L = 8'$. $B = 2\frac{1}{2}$".

$D = \frac{8}{\sqrt[4]{2\frac{1}{2}}} \times 0{\cdot}72 = \frac{8}{1{\cdot}3572} \times 0{\cdot}72 = 5{\cdot}89 \times 0{\cdot}72 = 4{\cdot}24"$.

This would be $4\frac{1}{4}$" deep.

Ex. 9. Find depth of straining beam in Fig. 2.

$D = \sqrt{15} \times \sqrt{45} \times 0{\cdot}9 = \sqrt{15 \times 6{\cdot}708} \times 0{\cdot}9 = 10{\cdot}031 \times 0{\cdot}9 = 9{\cdot}03"$.

$B = \frac{7}{10}$ of $D = 9{\cdot}03" \times \frac{7}{10} = 6{\cdot}32$, about $6\frac{3}{8}$".

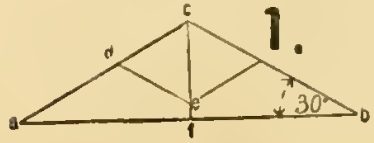
Ex. 10. If a king-bolt be used instead of a king-post for Fig. 1, find the diameter. $D = \sqrt{20} \times 0{\cdot}2 = 4{\cdot}472 \times 0{\cdot}2 = 0{\cdot}894$, or a fraction over $\frac{7}{8}$".

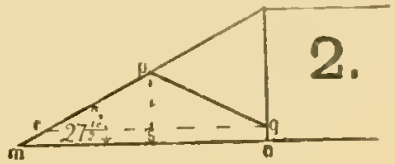
Ex. 11. If queen bolts be used instead of queen posts for Fig. 2, find the diameter. $D = \sqrt{15} \times 0{\cdot}29 = 3{\cdot}873 \times 0{\cdot}29 = 1{\cdot}123$, or $1\frac{1}{8}$" diameter.

When the base of a right-angled triangle, as a f, Fig. 1, is given, and the angle at the base, the length of the hypothenuse a c may be found by multiplying the base a f by the number given in the column opposite 30°.

To find the length of the perpendicular, as c f, Fig. 1, when the length of the base a f is given; multiply the base a f by the number opposite the angle given, and the product will be the length c f.

Multiplier for Hypothenuse.				Multiplier for Perpendicular.			
Angle.		Angle.		Angle.		Angle.	
20°	1·0642	35°	1·2208	20°	0·3640	35°	0·7002
$22\frac{1}{2}$	1·0824	$37\frac{1}{2}$	1·2605	$22\frac{1}{2}$	0·4142	$37\frac{1}{2}$	0·7673
25	1·1034	40	1·3054	25	0·4663	40	0·8391
$27\frac{1}{2}$	1·1274	45	1·4142	$27\frac{1}{2}$	0·5206	45	1·0000
30	1·1547	50	1·5557	30	0·5774	50	1·1918
$32\frac{1}{2}$	1·1857	60	2·0000	$32\frac{1}{2}$	0·6371	60	1·7321





TRANSVERSE STRENGTH OF RECTANGULAR BEAMS.

Beams supported at the ends and loaded in the middle.

For ordinary beams the best proportion is as 5 : 7 (*i.e.*) the breadth 5 and the depth 7. In such as common floor joists, &c., they are often as 5 : 18 and even more, and are prevented from buckling by bridging, or other lateral support.

A well-known formula for determining the breaking weight of wooden beams is as follows: $W = \frac{b \times d^2 \times c}{L}$; W is the weight in cwts. on the centre, b is the breadth in inches, d depth in inches, c a constant found by experiment, L length in feet between the supports.

From the above it will be seen that the breaking weight of a rectangular beam varies as the breadth and the square of the depth and inversely as the length.

The constant may be found by taking a bar one inch square, twelve inches between the supports, and weight it in the centre until it breaks. The weight that breaks it is the constant. Oak, Pitch Pine, and good Memel, c equals 5 cwts. Red Pine or Red Deal c is 4. Yellow Pine and White Deal c is 3. The constant being in cwts., the answer or breaking weight is in cwts.

According to the above formula, the breaking weight of a Pitch Pine beam 20′ long, 12″ deep, and 9″ broad would be as follows:

(1) $W = \frac{b \times d^2 \times c}{L} = \frac{9 \times 144 \times 5}{20} = 324$ cwts. Let the same beam be placed on its side, then the breaking weight would $= \frac{12 \times 81 \times 5}{20} = 243$ cwts. as against 324 cwts.

It is a well-known fact that the weight may be doubled if it be equally distributed over the full length.

If the beam be fixed at both ends, fifty per cent. of the weight (found by the above rule) may be added. If fixed at one end and supported at the other then twenty-five per cent. of the original weight may be added.

When all the terms except one are known the other may be found as follows. (*In the case just gone through the unknown term or quantity was W.*)

(2) Let it be required to find the length L, multiply the breadth by the square of the depth, and this product by the constant, and divide this result by the weight, and the product will be the length in feet.

(3) To find the breadth, multiply the length by the breaking weight, and divide this by the square of the depth multiplied by the constant; the result will be the breadth in inches.

(4) To find the constant, multiply the length by the breaking weight, and divide this by the square of the depth multiplied by the breadth; the answer will be the constant.

(5) To find the depth, multiply the length by the breaking weight, and divide this by the breadth multiplied by the constant; the square root of this result will be the depth in inches.

The above terms can be expressed in a legible and condensed form as follows.

(1) $W = \frac{b \times d^2 \times c}{L}$ (2) $L = \frac{b \times d^2 \times c}{W}$ (3) $b = \frac{L \times W}{c \times d^2}$ (4) $c = \frac{L \times W}{b \times d^2}$

(5) $d = \sqrt{\frac{L \times W}{c \times b}}$

(2) Let it be required to find the length of a beam when $W = 327\frac{3}{11}$ cwts. $d = 12''$. $b = 10''$ and $c = 5$. $L = \frac{b \times d^2 \times c}{W} = \frac{10 \times 144 \times 5}{327\frac{3}{11}} = 22$ feet.

(3) To find the breadth, let $L = 16'$, $d = 9''$, $W = 125$, $c = 5$: $b = \frac{L \times W}{c \times d^2} = \frac{16 \times 125}{5 \times 81} = \frac{400}{81} = 4\frac{76}{81}''$

(4) To find the constant when $L = 20'$, $d = 12''$, $b = 5''$, and $W = 144$ cwts. $c = \frac{L \times W}{b \times d^2} = \frac{20 \times 144}{5 \times 144} = 4$.

(5) To find the depth, let $L = 18'$, $b = 6''$, $c = 4\frac{1}{2}$, and $W = 150$. $d = \sqrt{\frac{L \times W}{b \times c}} = \sqrt{\frac{18 \times 150}{6 \times 4\frac{1}{2}}} = \sqrt{100} = 10''$

At the commencement it was stated that the best form of rectangular beam was when the breadth and depth was as 5 to 7.

In the examples just worked out all the terms were known except one. Let it be required to find the breadth and depth of a rectangular beam when the length, breaking weight, and the constant are given, and the breadth and depth to be as 5 to 7.

Let $L = 18'$, $c = 5$, $W = 68\frac{1}{18}$ cwts.

By general formula, breaking weight $= \frac{b \times d^2 \times c}{L}$

Substitute $\frac{5}{7}d$ in place of b, then breaking weight $= \frac{\frac{5}{7}d \times d^2 \times c}{L} = \frac{\frac{5}{7}d^3 \times c}{L}$

from which $d^3 = \frac{7}{5} \times \frac{W \times L}{c}$ and $d = \sqrt[3]{\frac{\frac{7}{5} \times W \times L}{c}} = \sqrt[3]{\frac{\frac{7}{5} \times 68\frac{1}{18} \times 18}{5}}$

$\sqrt[3]{343} = 7'' \therefore d = 7''$ and $7'' \times \frac{5}{7} = 5''$ the breadth.

When a beam rests upon two supports, one at each end, and has a uniform load; or if the weight be on the centre, then the reaction at each support will be equal to half the weight. If the weight be moved from the centre and placed nearer one of the supports, then the weight transmitted to each support will be in the inverse proportion to its distance from each end.

Example. Fig. 1. Let A B = 20′, W = 10 tons, and 10′ from each support, then the reaction or weight at $A = \frac{W \times B\,E}{AB} = \frac{10 \times 10}{20} = 5$ tons.

Reaction at $B = \frac{W \times A\,E}{A\,B} = \frac{10 \times 10}{20} = 5$ tons.

In a case like this it is well known that the weight at each end is equal to half the total weight, and the above calculation is not needed.

Fig. 2. Let the weight be placed at C, 4 from A, the reaction at $A = \frac{W \times BC}{AB} = \frac{10 \times 16}{20} = 8$ tons. Reaction at $B = \frac{W \times AC}{AB} = \frac{10 \times 4}{20} = 2$ tons. It will be seen that the sum of the two, equals the original weight, 10 tons. These must always equal the original weight; further, the reaction at A (Fig. 2) × A C = reaction at B × B C.

Fig. 3. Is an example when three weights are placed on a similar beam, A B = 20′, A C 4′, A D 12′, A E 18′. W at C, 7 tons, W at D, 18 tons, W at E, 5 tons.

The reaction at A and B may be found by taking each weight separately, and worked out the same as Fig. 2, and add the results together.

Instead of this collect the terms as follows: reaction at A × AB = W at C × B C + W at D × B D + W at E × B E; = 7 × 16 + 18 × 8 + 5 × 2 = 112 + 144 + 10 = Reaction at A = 266; $\frac{266}{20} = 13\frac{3}{10}$ tons. Reaction at B × A B = W at C × A C + W at D × A D + W at E × A E = 7 × 4 + 18 × 12 + 5 × 18 = 28 + 216 + 90 = Reaction at B = 334; $\frac{334}{20} = 16\frac{7}{10}$ tons. In this the pressure at each wall due to the weights alone is found, if the weight of the beam had been taken into account, then one half of its weight would have to be added to each of the weights determined by the above rule.

Let it be required to find the strain at E, Fig. 1, that is the bending moment. The strain at any point is equal to the reaction at the support multiplied by its distance from the point selected.

Thus reaction at A = 5 tons, then 5 × 10 = 50 ft. tons strain at E.

To find the strain at C, Fig. 1, let A C = 4′, then 5 × 4 = 20 ft. tons strain at C.

To find the strain at D, when B D = 3′, then 5 × 3 = 15 ft. tons strain at D.

It will be seen from this that the weight was not intercepted between the support and point selected. Should this not be applicable, and a weight is intercepted, as for example in Fig. 1, work from the end B, and prove that the strain at C is 20 ft. tons, when the reaction at B was 5 tons, and B C 16′. Strain at C = reaction at B × B C − W at E × C E = 5 × 16 − 10 × 6 = 80 − 60 = 20 ft. tons. The 10 tons placed on the centre produced a strain of 50 ft. tons. In Fig. 2, when the weight is 4′ from one end, the strain at the centre is only 20 ft. tons.

Thus reaction at B = 2 tons, then 2 × 10 = 20 ft. tons strain.

The strain at C is equal to reaction at A × AC = 8 × 4 = 32 tons strain at C.

From the above it will be seen that the weight should be kept as far as possible from the centre.

The strain at any point may be determined without finding the reaction at the supports.

Strain at E, Fig. 1 $= \frac{W \times A\,E \times B\,E}{A\,B} = \frac{10 \times 10 \times 10}{20} = 50$ ft. tons. Strain at $C = \frac{W \times A\,C \times B\,E}{A\,B} = \frac{10 \times 4 \times 10}{20} = 20$ ft. tons. Strain at $D = \frac{W \times A\,E \times B\,D}{A\,B} = \frac{10 \times 3 \times 10}{20} = 15$ ft. tons.

Rule for determining the bending moment at any section.

When there are a number of weights on the beam as Fig. 3, multiply each force on one side of the point selected, by its distance from that section, and adding together all those moments; first those going or pushing up, and second those pushing down. (*The former are positive and the latter negative.*)

To determine the strains or bending moments at C, D, and E, Fig. 3.

Strain at C = reaction at A × A C = $13\frac{3}{10}$ tons × 4 = $53\frac{1}{2}$ ft. tons.

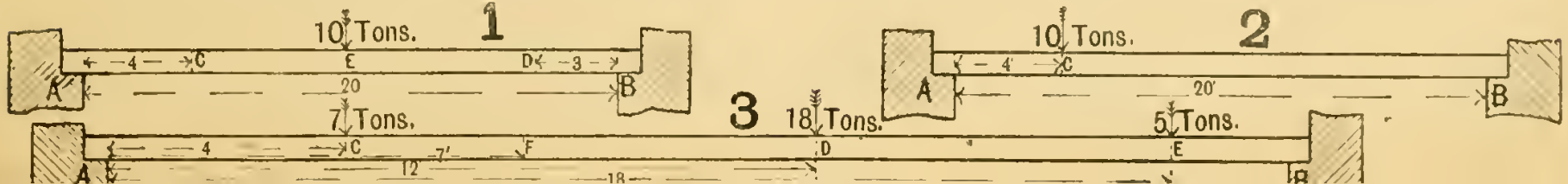
„ D = „ A × A D − W at C × C D = $(13\frac{3}{10} \times 12) - (7 \times 8) = 103\frac{3}{5}$ ft. tons.

Strain at E = „ A × A E − W at C × C E − W at D × D E = $13\frac{3}{10} \times 18 - 7 \times 14 - 18 \times 6 = 239{\cdot}4 - 98 - 108 = 33{\cdot}4$ ft. tons.

Proof. The strain at E = reaction at B × B E = $16\frac{7}{10} \times 2 = 33{\cdot}4$ ft. tons.

To determine the strain or bending moment at any other point as at F. Bending moment at F = reaction at A × A F − W at C × C F = $13\frac{3}{10} \times 7 - 7 \times 3 = 93{\cdot}1 - 21 = 72{\cdot}1$ ft. tons.

This may be proved by taking moments on the other side of the section thus. Bending moment at F = reaction at B × B F − W at D × D F − W at E × E F = 16 7 × 13 − 18 × 5 − 5 × 11 = 217 1 − 90 − 55 = 72·1 ft. tons.



STRENGTH OF BEAMS.—*Continued.*

Fig 1. What will the breaking weight be, when L 14′; b 10″, d 12″, c 5, l' 4′ and l'' 10′. Note l' and l'' are the two segments into which the beam is divided by the weight.

$W = \frac{b \times d^2 \times c \times L}{4 \times l' \times l''}$ This is on the principle of the cantilever.

$W = \frac{10 \times 144 \times 5 \times 14}{4 \times 4 \times 10} = 18 \times 5 \times 14 = 630$ cwts.

The above formula may be proved by taking the weight at the centre.

$W = \frac{b \times d^2 \times c \times L}{4 \times l' \times l''} = \frac{10 \times 144 \times 5 \times 14}{4 \times 7 \times 7} = \frac{25 \times 144}{7} = 514\frac{2}{7}$ cwts.

Take the formula for the breaking weight of a beam loaded at the centre.

$W = \frac{b \times d^2 \times c}{L} = \frac{10 \times 144 \times 5}{14} = \frac{25 \times 144}{7} = 514\frac{2}{7}$ cwts.

Fig. 2. Let it be required to find the breaking weight of a girder 18′ long, and loaded at two points, say 6′ from each end, d 14″, b 9″, and c 5.

Let W = one of the weights; then $R_1 = R_2$ these are the reactions $= \frac{W + W}{2} = W$; greatest B. M. $= R_1 \times \frac{L}{3} = \frac{W \times L}{3}$;

Let W′ = weight at centre to give the same bending moment; $W' = \frac{b \times d^2 \times c}{L}$; B. M. $= \frac{W'}{2} \times \frac{L}{2} = \frac{b \times d^2 \times c}{2L} \times \frac{L}{2} = \frac{b \times d^2 \times c}{4}$;

These bending moments must be equal $\therefore \frac{W \times L}{3} = \frac{b \times d^2 \times c}{4}$

$W = \frac{3}{4} \times \frac{b \times d^2 \times c}{L} = \frac{3}{4} \times \frac{9 \times 14^2 \times 5}{18} = \frac{3 \times 49 \times 5}{2} = 367\frac{1}{2}$ cwts. at one point, total load = 735 cwts.

The breaking weight of such a beam loaded at the centre would equal $\frac{9 \times 14^2 \times 5}{18} = 98 \times 5 = 490$ cwts., against 735 cwts.

The bending moment in foot cwts. when loaded at the centre = Reaction at the support $\times \frac{L}{2} = 245 \times 9 = 2205$ ft. cwts.

The bending moment at either point when loaded with the two weights = Reaction at the support × A C, or B D = $367\frac{1}{2} \times 6 = 2205$ ft. cwts. This proves that the bending moments are equal; when the breaking weight is ascertained for the centre or any other point. In this the bending moment is the same at any point between the two weights. Thus, bending moment at the centre = Reaction $\times \frac{L}{2}$ − W at C × by distance of C from the centre = $367\frac{1}{2} \times 9 - 367\frac{1}{2} \times 3 = 3307\frac{1}{2} - 1102\frac{1}{2} = 2205$ ft. cwts.

The above method of loading the beam is a familiar example in a framed floor; the two points being the intersection of the binders with the girder.

Fig. 3. A beam 20′ bearing, 15″ deep, 9″ broad, c 5, is loaded at two points C and E; C being 4′ from A, and the weight 300 cwts.; E is 3′ from B, and the weight 240 cwts. What extra weight may be placed at the centre, so that it may be on the point of breaking.

Let W″ = the additional weight placed at D, 11′ from A.

Breaking weight of the beam loaded at the centre is $W = \frac{b \times d^2 \times c}{L}$

$= \frac{9 \times 15^2 \times 5}{20} = \frac{2025}{4} = 506\frac{1}{4}$ cwts.

Bending moment at the centre = $R_1 \times \frac{L}{2} = \frac{W}{2} \times \frac{L}{2} = \frac{506\frac{1}{4}}{2} \times \frac{20}{2}$

$= 253\frac{1}{8} \times 10 = 2531\frac{1}{4}$ ft. cwts.

In the given example taking moments about A, and let W″ = the weight required at D, 11′ from A.

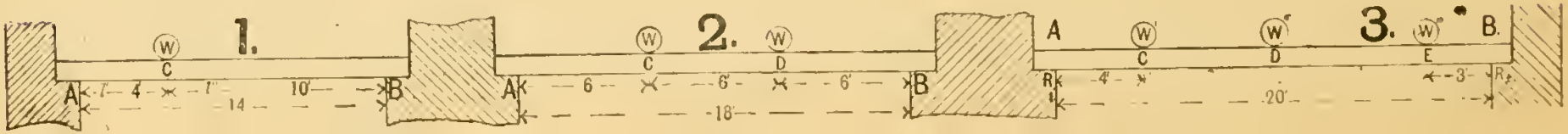
$R_2 \times A B = W' \times A C + W'' \times A D + W''' \times A E$; $R_2 \times 20 = 300 \times 4 + W'' \times 11 + 240 \times 17$.

$20 \times R_2 = 1200 + W'' \times 11 + 4080$; $R_2 = W'' \times \frac{11}{20} + \frac{5280}{20} = W'' \times \cdot 55 + 264$.

Greatest bending moment (which is at D) = $R_2 \times B D - W''' \times E D = (W'' \times \cdot 55 + 264) \times 9 - 240 \times 6 = W'' \times 4 \cdot 95 + 2376 - 1440 = W'' \times 4 \cdot 95 + 936$.

These bending moments must be equal.

$\therefore W'' \times 4 \cdot 95 + 936 = 2531\frac{1}{4}$; $W'' \times 4 \cdot 95 = 1595 \cdot 95$; $W'' = 322 \cdot 2727$ cwts.



STRENGTH OF BEAMS.—*Continued.*

In the previous examples the beams were to be used for floors and similar purposes; *i.e.*, they were to be horizontal. If a beam has to be inclined then the rule given requires to be modified, as the breaking weight varies with the angle of inclination.

For inclined beams as Fig. 1, it is convenient to find the breaking weight of the beam when laid horizontal, and multiply this by the number in the column opposite the angle of inclination. The result will be the breaking weight.

Fig. 1. Ex. 1. Let it be required to find the breaking weight of a beam 16′ long, 4″ broad, 8″ deep and c 5, when inclined say (a) 30° (b) 45° and (c) 60°. The breaking weight when placed horizontal would be:

$W = (b \times d^2 \times c) \div L = (4 \times 64 \times 5) \div 16 = 80$ cwts.

Breaking weight when inclined at 30° $= 80 \times 1{\cdot}1547 = 92{\cdot}376$ cwts.

Ex. 2. If the inclination be 45°, the breaking weight will be $80 \times 1{\cdot}4142 = 113{\cdot}136$ cwts.

The number is taken from the column opposite 45°.

Ex. 3. If the inclination be increased to 60° the breaking weight will be $80 \times 2{\cdot}0000 = 160$ cwts.

If the beam be loaded at a point near one end, the breaking weight must be found in the same manner as Fig. 1, page 64, and the result multiplied by the necessary number.

If the beam be loaded at a few points the breaking weight must be found similar to Fig. 3, page 64, and for the final breaking weight multiply the result by the number opposite the angle.

When the breaking weight of a horizontal beam has been determined, its breaking weight when inclined may be found graphically.

Fig. 2, Ex. 4. Let the line A B represent to any convenient scale, the breaking weight of the beam when horizontal; let it be required to find its breaking weight when the end B has been lifted up to B^1. Erect a perpendicular from B and produce A B^1 to meet the perpendicular, the point where these meet is marked C; then A C represents to the same scale the breaking weight of the beam when inclined as shown. If necessary, C may be constructed into A B, produced to C^1.

It will be found on measuring the lines that A B is 4 and A C $5\frac{1}{4}$.

The above may be expressed as follows, as A B : A C : : the breaking weight of the horizontal beam, to the beam when inclined.

As A B : 80 : : A C or A C′ to the breaking weight when inclined as A B′; breaking weight $= (80 \times 5\frac{1}{4}) \div 4 = 105$ cwts.

Ex. 5. The bending moment at the centre of a wooden girder 20′ long, is 100 ft. cwts. What weight placed at the centre will produce this bending moment?

W = Reaction at one end × 2; B. M. = Reaction $\times \frac{L}{2}$

Reaction = B. M. $\div \frac{L}{2} = 100 \div 10 = 10$ cwts; W = 10 × 2 = 20 cwts.

Ex. 6. The bending moment at the centre of a joist 14′ long is 26 ft. cwts; the weight being placed at the centre. What will the bending moment in ft. cwts. be, 3′ from one end?

B. M. = Reaction $\times \frac{L}{2}$; Reaction = B. M. $\div \frac{L}{2} = 26 \div 7 = 3\frac{5}{7}$ cwts.

B. M. 3′ from one end $= 3\frac{5}{7} \times 3 = 11\frac{1}{7}$ ft. cwts.

Ex. 7. The bending moment at the centre of a wooden girder 20′ long is 35 ft. cwts.; the weight being uniformly distributed. What is the bending moment in ft. cwts., 7′ from one end?

As the square of half the span : the product of the two distances (l, $l_{,,}$) of the section : : the bending moment at the centre : the bending moment at the section.

$\left(\frac{L}{2}\right)^2 : l, \times l_{,,} : :$ B.M. at centre : required B.M.

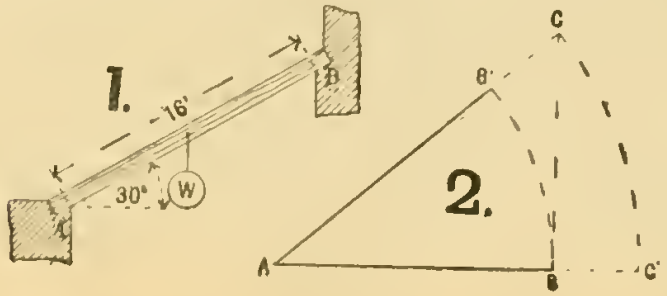
$10^2 : 7 \times 13 : : 35 :$ required B.M.

$$\text{B.M.} = \frac{7 \times 13 \times 35}{100} = \frac{3185}{100} = 31{\cdot}85 \text{ ft. cwts.}$$

In several examples the bending moment was determined and expressed as follows: Say B. M. = 36 ft. cwts. The meaning of this phrase is that the unit of length used is one foot, and the unit of weight one hundredweight.

If it had been say B. M. = 3578 in. lbs., then the unit of length had been 1″ and the unit of weight 1 lb.

Any unit of length may be used and any unit of weight; but the bending moment must be expressed in terms of the units used.



STRENGTH OF BEAMS.—*Continued.*

The following Examples are from previous Examination Papers :—

Exercise 1. Give the rule for comparing the strength of rectangular wooden beams. Let B W represent the breaking weight. Then (B W No, 1.) : (B W No. 2.)$=\frac{b_1 \times d_1^2}{L_1} : \frac{b_2 \times d_2^2}{L_2}$ Substitute the numbers in the question for the letters, and reduce the ratio to its lowest terms.

Exercise 2. A contractor put up a beam 9″ × 10″ over a 10′ opening instead of a 6″ × 12″, as specified and maintained that it was the stronger section of the two. Compare the relative strength of the two beams.

$\left\{\begin{matrix}\text{Breaking weight}\\ \text{of beam put up}\end{matrix}\right\} = \frac{9 \times 10^2}{10} = 90.$ $\left\{\begin{matrix}\text{Breaking weight}\\ \text{of beam specified}\end{matrix}\right\} = \frac{6 \times 12^2}{10} = 86{\cdot}4.$

Their breaking weights are as 90 : 86·4 = 900 : 864 = 25 : 24. Hence the contractor was right as regards strength but wrong as to economy.

Exercise 3. A beam rests on two supports A and B, 16′ apart, carries a load of 1½ tons at a point 4′ from A, and a uniform load of 2 cwts. per foot run from B up to the centre. Determine the proportion of the loads transmitted to A and B.

Reactions due to the distributed load are the same as if the load was concentrated at a point one-fourth the length of beam from B.

Distributed load = 112 × 2 × 8 = 1792 lbs.

Taking moments about B ; (Reaction at A) × 16 = (3360 × 12) + (1792 × 4) ;

Reaction at A $= \frac{40320 + 7168}{16} = \frac{47488}{16} = 2968$ lbs.

Reaction at B = 3360 + 1792 − 2968 = 2184 lbs.

Exercise 4. A Beam has safely carried a centre load of 4 tons over a 6 span, what uniformly distributed load would you consider it safe to put over a 12′ span ?

Centre load for a 12′ span = half centre load for a 6′ span = ½ tons = 2 tons.

Distributed load for 12′ span = twice centre load.

∴ Required load = (2 × 2) tons = 4 tons.

Exercise 5. Supposing the sectional area of a timber girder to be 90 square inches, give the dimensions of depth and width which in your opinion will produce the strongest section.

Theoretically the strongest section would be when the depth was very great and the breadth narrow ; still the same sectional area ; because the strength increases as the square of the depth, and directly as the breadth. In practice, for ordinary rectangular beams, such as girders, &c., the breadth and depth should be as 5 : 7.

Let $5x$ and $7x$ be the required dimensions, then $5x \times 7x = 90$; $35x^2 = 90$; $x^2 = \frac{90}{35} = \frac{18}{7} = 2{\cdot}5714$; $x = \sqrt{2{\cdot}5714} = 1{\cdot}6036$; $5x = 8{\cdot}018$; $7x = 11{\cdot}225$.

Proof :—8·018 × 11·225 = 90·002 square inches.

Exercise 6. What would be the breadth of a fir girder according to the following dimensions : $\frac{74\,L^2}{d^3} = b$. L = length in feet = 15 feet, d = depth in inches = 12 inches, b = breadth in inches.

$$b = \frac{74\,L^2}{d^3} = \frac{74 \times 15^2}{12^3} = \frac{74 \times 225}{1728} = \frac{37 \times 25}{96} = \frac{925}{96} = 9{\cdot}64 \text{ inches.}$$

Exercise 7. A Girder 20′ span rests on two supports at its ends A and B, carries a weight of 3 cwts. 5′ from A, at the centre a load of 5 cwts., and 5′ from B, a load of 7 cwts. Give the reactions at A and B and the shearing stress to which the girder is exposed between the centre and the load of 7 cwts.

Taking moments about A ; Reaction at B × 20 = (3 × 5) + (5 × 10) + (7 × 15) ; Reaction at $B = \frac{15 + 50 + 105}{20} = \frac{170}{20} = 8{\cdot}5$ tons.

Reaction at A = (3 + 5 + 7) − 8·5 = 6·5 tons.

Shearing stress = 8·5 − 7 = 1·5 tons.

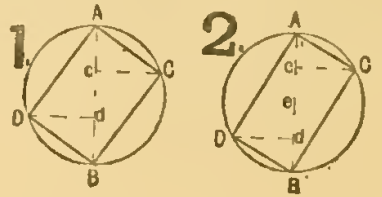
Or taking the other end. Shearing stress = 3 + 5 − 6·5 = 1·5 tons.

For fuller information on the reaction at each support see chapters on the strength of rectangular beams.

For shearing stress at various points see Graphic Statics.

Fig. 1. The strongest rectangular beam that can be cut out of a circular log is obtained as follows : Draw any diameter as A B and divide it into three equal parts in the points c d, erect perpendiculars from c and d to cut the circumference in C and D ; then the log A C B D will have the strongest section, i.e., b × d² will be a maximum.

Fig. 2. For the stiffest, divide the diameter A B into four equal parts at c e d, from c and d erect perpendiculars to cut the circumference in points C and D. The rectangle A C B D will be the stiffest section that can be cut out of the log, i.e., b × d³ will be a maximum.



CANTILEVERS.

Cantilevers are beams fixed at one end, the other end being unsupported, see Figs. 1 to 5.

Fig. 1. Find the breaking weight of the given cantilever when L is 9′ depth 9″, breadth 4″, and c 5, the weight to be applied at the extreme end as shown. $W = b \times d^2 \times c \div (l \times L) = 4 \times 81 \times 5 \div 36 = 9 \times 5 = 45$ cwts.

It will be seen from this that a beam fixed in this way is only one-fourth the strength of a similar beam supported at each end.

Find the depth of a similar cantilever when W = 45 cwts.

$d^2 = W \times 4 \times L \div (b \times c)$; $d = \sqrt{45 \times 36 \div 20} = \sqrt{9 \times 9} = \sqrt{81} = 9''$.

Find the length; W = 45 cwts, d 9″, b 4″, and c 5.

$$4 \times L = \frac{b \times d^2 \times c}{W} = \frac{4 \times 81 \times 5}{45} = 36,\ L = \frac{36}{4} = 9'.$$

The breadth and constant may be found in a similar manner.

Fig. 2. Shows a cantilever similar to Fig. 1, but in this case the weight is equally distributed. When the weight is spread out in this manner it would take 90 cwts. to produce the same strain that the 45 cwts. did in the first example. It takes double the weight when distributed to a concentrated weight at the extreme end.

Fig. 3. What would be the strain at the wall produced by W″ which is 9 cwts. and 12′ from the wall, and W′, which is 6 cwts. and 8′ from the wall.

B. M. at the wall due to the 9 cwts. l''' from the wall $= l''' \times W = 9 \times 12 = 108$ ft. cwts. B. M. at the wall due to the 6 cwts. l'' from the wall $= l'' \times 6 = 8 \times 6 = 48$ ft. cwts. $108 + 48 = 156$ ft. cwts.

What weight placed at a distance l' from the wall would produce the same strain. This weight is shown 3′ from the wall and by the dotted circle, W required $= 156 \div l' = 156 \div 3 = 52$ cwts.

Fig. 4. Shows the side elevation of a wooden cantilever of uniform strength taken at any point. In order to determine the depth at a few points, say x and y, loaded as Fig. 1.

Rule.—To find depth at any section, square the depth at the wall, and multiply by the distance selected from the unsupported end, divide this product by the total length; the square root of the last result is the depth at the section selected.

Find depth at X, 2′ from A, i.e., 7′ from the end. Total length, 9′.

Depth at $X = \sqrt{12^2 \times 7 \div 9} = \sqrt{144 \times 7 \div 9} = \sqrt{112} = 10{\cdot}58''$.

Find depth at Y, 6′ from the wall, i.e., 3′ from the end.

Depth at $Y = \sqrt{12^2 \times 3 \div 9} = \sqrt{144 \times 3 \div 9} = \sqrt{48} = 6{\cdot}93''$.

The above may be expressed as follows:

Find depth at X. $9 \times W : 7 \times W :: 12^2 : d^2$

Find depth at Y. $9 \times W : 3 \times W :: 12^2 : d^2$

Or let x = the depth at the wall, and l the distance of X from the end and L the total length. Then depth at $X = x^2 \times l \div L$.

The drawing is out of proportion in order to show the curve and the depths at X and Y.

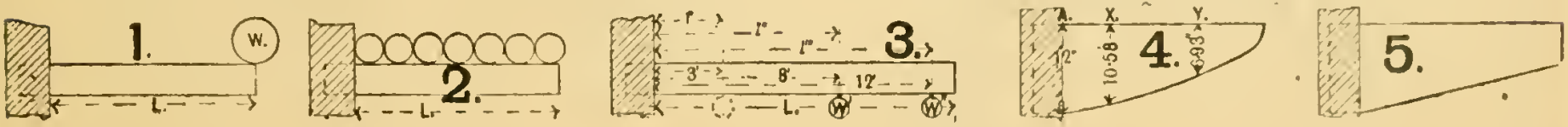
Fig. 5. Shows a side view of a cantilever similar in principle to the last, instead of curving the bottom side make the depth at the end half the depth that the cantilever is at the wall, and draw a straight line as shown.

Ex. A cantilever, 8′ long, is fixed into a wall and loaded at its unsupported end to its limit of safety. If the load was moved to a point 6′ from the fixed end, what additional weight in the shape of a uniform load could be added to the beam without exceeding the limit of safety. Let X represent the required weight.

B. M. of the original load $= W \times 8$; B. M. of removed and added load $= w \times 6 + X \times 4$. $2W = 4X$. $X = \frac{2W}{4} = \frac{W}{2}$

Proof.—Let W = 5 tons, then B. M. in the first case $= 8 \times 5 = 40$ ft. tons.

B. M. in second case $= 6 \times 5 + 2\frac{1}{2} \times 4$, $X = 30 + 10 = 40$ ft. tons, therefore the required additional load is half the original load.



CUTTING UP TIMBER,

Or what is termed the conversion of timber, is the reducing of logs, &c., to planks, deals, battens, &c.

Fig. 1. Represents a cross section of an ordinary tree, let it be required to get as many 3″ planks as possible out of this as shown, and marked A, B, C, and D.

Fig. 2. Shows what these planks would be like when they have been seasoned. The centre plank A will remain full width and full thickness in the centre. B will be reduced in width and the edges will be thinner than the centre, and worse still the side next the heart will shrink less than the outside, this causes the plank to be of the shape shown. C and D follow the same rules, and will be similar to sketches. This is most marked in oak, ash, and some of the British grown timber.

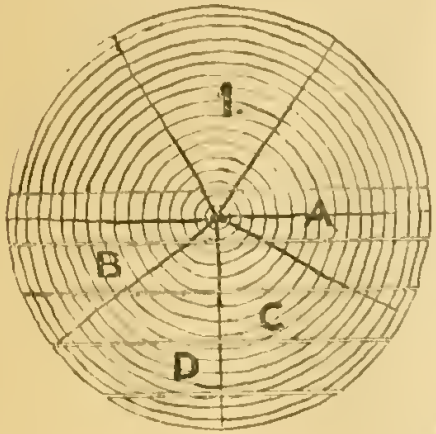
Fig. 3. Shows how a tree should be cut up when quality is to be preferred to quantity. In oak, for instance, there are radial lines from the centre towards the circumference, and when a side of a board is parallel to one of these lines a beautiful figured surface is shown. This is known as the silver grain or felt. If only one side has to be seen, then it should be cut as shown on the top half, the side A would be the richest in figure and far superior to the side B, though the board might only be 1″ thick.

If first-class flooring boards, framing panels, &c., are required, that are to be level and not shrink in width or curl up, then the log would have to be cut as shown at C and D, the space between them being cut into narrower boards. It will be seen in this method of cutting up that there is great waste of timber and extra labour; this is only carried out in exceptional cases.

For fair average floors the boards are cut as shown at E, and are called quarter cut. The board at F would curl up in the usual way, but would be stronger on edge than any of the three as A B, C, or D.

Fig. 4. Shows what the boards would be like after seasoning. F is the usual curved shape, being parallel to an axis and a good distance from that axis. G and H show what the boards would be like, see E, Fig. 3, they would shrink a little in width, and tend to be thinner at one edge; on the whole these boards lie fairly level and are much cheaper than such as C and D, Fig. 3.

Fig. 5. Shows a tree with a wandering heart, these though crooked when young, fill up or become nearly straight. If a board be cut out of such a tree it appears as shown at F, a board like this would be sure to twist, because at X and X it is through the centre and would remain flat; at Y it is away from the pith and would turn up at the edges the side next the heart would be round. J shows what a board would be like if cut from the outside of a straight tree, as F in Fig. 3. K shows what one like A, Fig. 2, would be after being seasoned.



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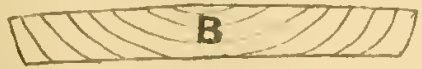
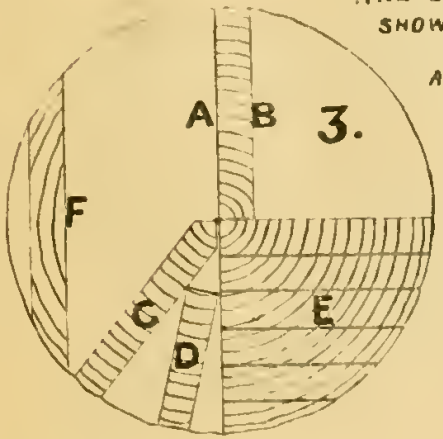


2 & 4
ARE EXAGGERATED TO
SHOW HOW THE PLANKS
APPEAR WHEN
SEASONED.



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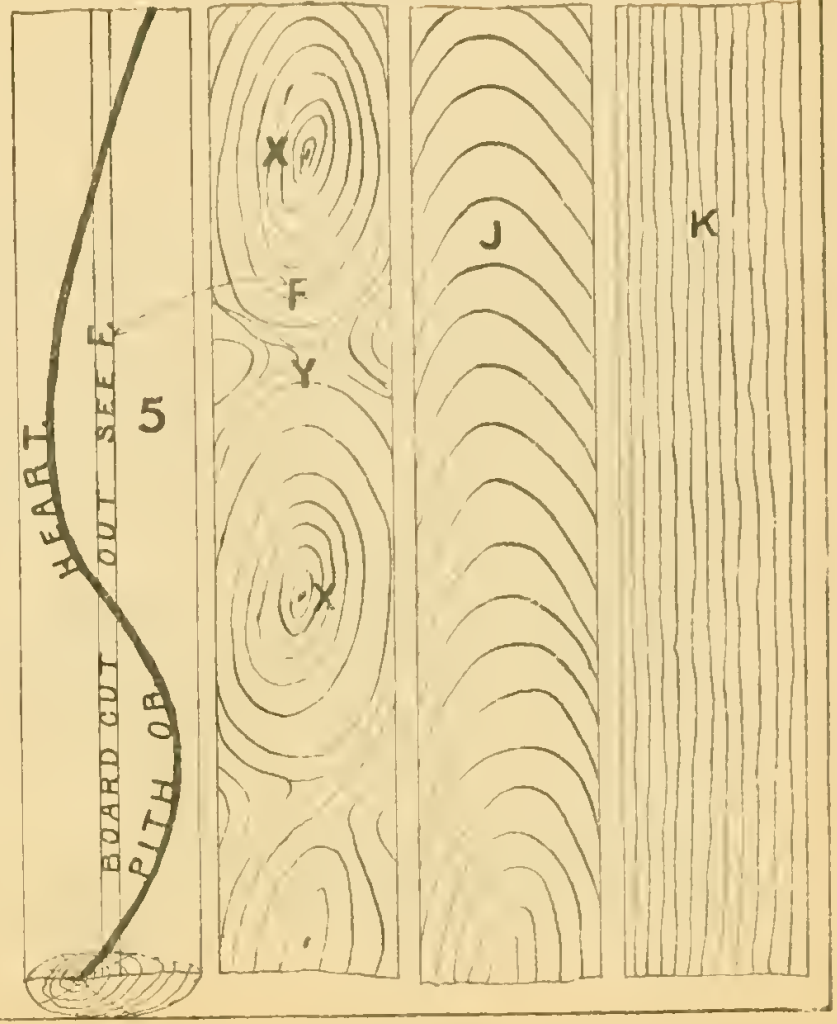


NOTES ON TIMBER.

In treating this branch of the subject, it is the author's intention only to give a brief description of a few of those in general use by the builder; leaving specialities and rare varieties to more extensive books.

SOFT WOOD.

White Fir or Spruce.

Is the product of a tree found in this country, **North America, Norway,** and in many parts of **North Europe.**

The Spruce tree grows to a good height, but tends to a conical shape, if not restrained by other trees in close proximity. It is at its best from 70 to 80 years of age; has a large number of branches, hence the wood is full of knots. The Spruce tree in this country is generally found in parks, &c., and is not cultivated for the value of its timber.

The colour of the timber is a brownish white, the darker portion of the annual rings when sawn or planed forms light brown streaks on the surface. The sap wood is not easily distinguished from the heart wood until seasoned, when it becomes blue, and sometimes brown.

The knots are distinct and hard, shrink very much in seasoning, and many fall out. The timber contains resin, which is generally found in blisters, between the annual rings. A cross section shows the annual rings to be very distinct.

There are two kinds in **America**; but the timber is the same, the colour does not go further than the bark.

The timber is wanting in strength and durability.

The **American** Spruce comes chiefly from **Canada and New Brunswick.**

The foreign Spruce that arrives in our markets is chiefly in planks, deals, or battens, a white deal log being a rare thing.

BALTIC SPRUCE. This is chiefly from **Norway,** and arrives in our markets similar to the above, also a large quantity of cheap match, or matched boards grooved and tongued, and a large quantity of boards which are generally used for common flooring and temporary purposes. The best white deal flooring boards come from **Christiania;** these are cut from the best trees.

The best **Russian** white deal is shipped from **Onega.**

The **Petersburgh** white deal cannot be relied upon, as it is continually contracting and expanding according as the weather is dry or wet. Of all the white deal this is the finest and closest grained. The **Riga** white being from a tree that grows quickly, the wood is open grained, easier to work, but not so strong as that from **Petersburgh.**

The surface of white deal, when planed, is firm, clean and bright, and well adapted for table and dresser tops, shelves for cupboards, and any place where bread, meat, or eatables are likely to be stored, as it does not give off any resinous smell.

It is not adapted for framing such as doors, &c., owing to its liability to warp, a small quantity is used for panels, and where free from knots it may be used for common moulds; though the black knots will spoil any machine irons. It is often used for stairs, ledge doors, and as glue adheres well to it, foundations or backs of parquetry are often made of it, also packing cases, &c. In joinery the extra cost in working it (compared with red deal) prevents its general use, as well as the other objections.

In carpentry it is used for common roofs such as small trusses, purlins, common rafters, slate battens, &c. It is also used for quarterings in partitions, for bridging joists and ceiling joists. It is not adapted for external work.

The planks of **Riga** white have a woolly surface. The white from **Petersburgh** is smooth, and the **American** is a medium between the other two.

Spruce or white deal planks may be easily distinguished from the red, or yellow pine planks, as the former are much lighter coloured than the latter.

Red or Yellow Fir.

This is known as red deal, red pine, or red wood. The term yellow pine is used to distinguish the lighter and less resinous from those containing more turpentine, and of stronger marked annual rings. The timber is cut from the **Scotch** fir or **Northern** pine. The difference in the timber is due to the soil in which the tree grows, and also the altitude at which it is grown.

The tree is found in **Scotland, America, Denmark, Norway, Sweden, Lapland, Russia, Prussia,** and **Poland.**

The red pine from foreign ports arrives in our markets, in masts, spars, balks, planks, &c.

The colour of the wood varies from a reddish yellow to almost as light as white deal. A cross section of one of the stronger grown trees shows it to consist of alternate dark and light rings; the dark part is harder than the light.

The best balks in our markets are from **Prussia,** and are shipped from **Dantzic** and **Memel.** (**Riga** is from **Russia.**)

Dantzic averages 30 to 45 feet in length, 13″ to 16″ square. This is the strongest. It is, however, subject to cup shakes, and often has a great number of large knots. If cut into deals they run from 18′ to 50′ long, and from 2″ to 5″ thick; they may be got longer, but are liable to be knotty towards the top end.

The timber lasts well when thoroughly seasoned, it is strong, elastic, and tough; as a rule it is good to work compared with white deal. In the smaller trees there is a great deal of sap wood, and this, when fresh cut, is very like the heart wood. As the timber gets older, or the plank or boards are seasoned, the sap wood turns blue. At the same time the heart wood turns somewhat brown.

Of the above three, **Dantzic** is the strongest and largest. **Memel** is very like the above, but finer in the grain. **Riga** is less than the others, the annual rings being very close. The balks average 12″ square, and are as long as 40′, has very little sap, is straight and free from knots; if only free from heart shakes it is excellent timber.

SWEDISH timber (*i.e.*) red deal. This is similar to the **Prussian**, but not so large or good. The trees taper very much, and the balks are not more than 10″ square. In general the heart wood is of a yellowish white colour, and the sapwood is of a blue shade, and easily distinguished from the heart-wood. It has few knots, and those are small. The timber is cheap, but it is only fit for common carpentry; being cheap, it is often used for purposes in which a superior class only should have been allowed.

In the **Prussian** and **Swedish** timber the knots are of a red colour, and firmly imbedded, and often merge gradually into the ordinary timber.

Russian Timber.

The red deals imported from **Petersburgh, Onega, Archangel**, &c., are similar in appearance to those from **Prussia** and **Sweden.** The timber from the northern ports being close-grained, hard, and good wearing, whilst those from the more southern ports are open-grained. The knots are a distinctive feature, and, in general, are encased by a ring of bark, as if the branch had penetrated the trunk of the tree. The knots soon get loose, and are liable to fall out.

The **Russian** timber from **Petersburgh** when free from knots and the heart, is excellent, and fit for any place where it is subject to great wear. If the heart is in a plank the timber is sure to be shaken when dry. The timber is liable to dry-rot, and is not suitable for damp situations.

American Timber.

RED DEAL, OR RED PINE. This timber is similar to that from the **Baltic**; but it is not so strong as the **Dantzic** and the other **Prussian** red deal. It grows in **Canada**, and is known as red pine; it has large knots, and though the bark is red, the timber, when new cut, is a reddish-white, clean, fine grained, and easily worked. In strength it is not equal to Dantzic, though it is stiffer as a post. Being easily worked, and the knots not too hard, it is valuable for joiner's work; especially where a stronger timber than yellow pine is required.

From the foregoing descriptions on red deal, it will be obvious that the most suitable timber for good buildings, such as churches, public buildings, and the heavier timber for principals, purlins, &c., should be of Crown Memel. Wherever extra quality, length, &c., are required, then an extra price must be paid; and the Crown Memel rarely gets further than the specification. For outside work this timber lasts well, when thoroughly seasoned and protected by paint. The commoner descriptions, such as **Swedish**, are used for all ordinary roofs, partitions, common or bridging joists, ceiling joists, &c. For girders, binders, and such like, these should be of good **Dantzic, Memel,** or **Riga.**

The **Russian** red deal makes good flooring boards. For dressed timbers, such as skylights, inside roof boarding, and such as match boards which are to be varnished, it is well adapted, as the grain of the wood shows through; the darker and lighter parts appear more distinct after it is varnished.

The **American** red, as previously stated, is not so strong as those just named, but it is easier to work, and very suitable for any internal joinery, as doors, door-frames, architraves, skirting-boards, moulds, dado boarding, or framing, and even for sashes and frames.

The first cost of red is a little more than white, but the former is easier to work and much more reliable, and when first cost and labour have been added, it will compare favourably as regards the ultimate cost.

It agrees well with glue; that is to be preferred which is free from knots and bright. Inferior descriptions choke the saw, have thick annual rings, and a good deal of resinous matter. **Swedish** timber, though tough, is liable to clog the saw.

Some authorities assert that good red deal is as durable as oak, this the author thinks is an exaggeration. The lasting properties of good red deal are not to be despised, as it has been found in roofs 300 years old apparently in as good condition as if it had been just imported.

Yellow Pine.

This timber is imported from the **Baltic** and **America.** The **American** yellow pine is cut from a tall and large tree found in **New Brunswick.** Lord Weymouth is said to have been the first to introduce the timber into this country, and many know it as Weymouth pine. Some of the finest trees are 250 feet high; there is no difficulty in getting logs 70′ long and 24″ square. The annual rings are not distinct, the colour is a brownish yellow and gets darker with age. It is the finest, softest, and easily worked timber we have, being soft and not much resin, it

agrees well with glue. It is well adapted for panels, framing, moulds, &c., it is not liable to twist, and lasts well when seasoned, but must not be used in the log, as it soon decays unless cut up. It is not so strong as red deal. The knots are red, and in some of the commoner descriptions they are almost black and liable to be loose.

The yellow pine, or yellow deal, from the **Baltic**, is similar to the common **American**, the former has more knots and is generally considered stronger. **American** yellow pine can be distinguished by short dark hair-like lines running in the direction of the grain.

Pitch Pine.

This timber is very like red deal, only the grain of the wood is more distinct, contains more resin or pitch, and is much heavier. The pitch pine grows in the **United States**, that from the Southern States of **North America** being the best. It is shipped from the ports of **Savannah, Darlen,** and **Pensacola**. The annual rings are very distinct and wide, and owing to the resin it is bad to work, as it has a greasy surface; neither glue nor paint adhere well to it. When good it is much used by the engineer, as it can be got in logs, 16″ square and 70′ long. It is treacherous and bad to judge in the log, as it may appear quite sound and when cut up it is often full of heart and cup shakes. It is best to get it in flitches or planks if small scantlings are required, in this way the shakes may be detected. The logs as a rule, are roughly hewn to an octagonal shape; the balks are sawn square, and may be had from 30 to 70 feet in length. The timber is free from knots, but it contains a large amount of sapwood; this is easily distinguished from the heart, as the sapwood is of a bluish colour, whilst the heart wood is of red colour. If the timber lies in a damp situation before it is cut up, the sapwood begins to decay. The timber is used by builders for all classes of work, as the heavier roof timber; girders and binders for floors, treads for stairs, newels and handrails. Owing to its rich colour, it is extensively used for varnished work, as roof boarding, dado, and all kinds of framing, even the very best doors. In doors and framed work an excellent effect may be obtained by making the framing of plain straight grained wood, and the panels of fine curled.

The richest kinds are scarcely surpassed by any timber; it takes a good polish, and looks well when new; but owing to the hard and soft rings, they do not remain alike, the lighter and soft parts shrink and the surface soon becomes uneven, as the darker or hard part remains firm. It is cheap, but as stated before, it is bad to work, and this keeps it out of more general use. It is strong, and very durable when kept free from damp. It is heavy, hard, and liable to be split by nailing, and when extra dry or aged it is very brittle.

HARD WOOD.

Ash.

The ash tree grows in **Asia, Great Britain, Hungary,** and **America.** The wood is very tough, elastic, and easily worked. The colour is of a light or brownish white whilst young, but turns brown with age, especially the heart wood. When the timber is young it does not appear to have any sapwood. The annual rings are distinct and separated from one another by a ring full of pores; the pores are very small, though otherwise they resemble the pores in a cane. It is not much used by the builder, though ash joists are said to bear a greater weight than any other **English** wood. It is used by the cabinet-maker for furniture. It is clean, hard, and beautifully marked, and takes a good polish. The Hungarian ash is one of the richest figured timbers we have, and is only used for ornamental purposes. The **English** ash is used by the wheelwright and agricultural implement maker for cart shafts, fellows for wheels, wheelbarrow shafts, &c., &c. Owing to its great elasticity it is well adapted for resisting sudden shocks. It is durable when well seasoned and kept dry, but cannot stand alternate wet and dry.

Alder.

The **English** alder is close and fine grained, the colour is of a reddish-yellow, it is soft and easily worked, lasts well if buried in wet ground. The timber has no odour, and is used for bowls, turning, and cabinet work, being light and tough; it is used for common floors, doors, and sides of carts for rough work.

Poplar.

This is found in most parts of **England.** The wood is of a light colour, close grain, and smooth when planed. It has no medullary rays, but the annual rings are distinct, as one side of each ring is a little darker than the other. Of all timber this is the nearest fireproof. It is only used in the immediate neighbourhood where it grows. Being light, tough, and not easily split, it is used for floors, very common or light doors, light barrow sides, and for sides and bottoms of common carts. It does not give off any odour, and is used for butter boxes, packing cases, &c.

Baywood.

This is a common kind of mahogany, and is found about the Bay of **Honduras** in Central **America.** The timber grows to a large size, and is of a fine, red-brown colour; and if well seasoned and kept dry the timber is very durable. The seasoning requires to be carried on gradually, otherwise it is liable to split. No timber takes glue better and it is not liable to twist. The builder uses it for counter and desk tops, best doors, newels and hand-

raile for stairs; where cost is not an objection it is used as a foundation for veneer, for such as Spanish mahogany, and the more costly and ornamental wood. The wood is good to work, and the commonest is nearly as white as yellow pine. The grain is fine and even, the best is of a dark red, tending to a wavy appearance, and the colour is brought out by oil, varnish, or polish. It is well adapted for polishing. Logs may be had 20′ long and 2′ 6″ square, and shorter logs may be had 6′ or 7′ square.

Mahogany.

Spanish Mahogany is from the **West Indies**, the principal or best comes from the Island of Cuba. It is a fine rich colour, darker, heavier, harder, and more wavy or festooned than the Baywood (or **Honduras** mahogany.) The **Spanish** or **Cuba** mahogany may always be known by the white chalk-like substance in the pores. It is one of the richest woods we have, but its cost prevents its use for any but ornamental purposes. The logs as a rule are 10 or 12 feet long and about 2 feet square.

Greenheart.

This is found in the **N.E.** portion of **South America**. The heart of the wood is of a dark green colour; when the timber gets old it turns black. A cross section shows that it is full of pores like a cane. As a pillar or post it is the strongest timber we have, but when it gives way it goes like a piece of cast-iron—that is, it gives no warning. The timber is clean fine grained, and very heavy; owing to an oily substance it burns well. It is bad to work, and the builder only uses it for such as treads for stairs, sills, and jambs for loading ways, or where any extraordinary wear is likely to occur.

Teak.

This comes from **India, Burmah**, &c., it is sometimes called **Indian Oak.** The dark timber is the strongest and heaviest. The wood has a fine straight grain, and if it had only medullary rays it might be passed for oak; but it does not corrode iron fastenings.

The colour is of a darkish brown; its texture uniform but porous; the annual rings narrow and regular. The timber is both strong and stiff. In working it no timber dulls the tools sooner; its expense prevents its general use. It is principally used for fitting up stables of the first class—owing to a strong odour the horses do not gnaw at it. A small quantity is used for fitting up shops.

Oak.

Of all timbers for constructive purposes this is the most valuable, no other timber can stand as many changes as this. In compression teak and greenheart stand highest, but fail in other respects, and so on through the list of timber. There are two principal varieties (*a*) the robur, or **stalk-fruited oak**; (*b*) the sessiliflora or **cluster-fruited oak.** The first is found in most of the temperate parts of **Europe**; that from **Sussex** is considered the best in **England.**

A cross section (see cutting up of timber) shows that the annual rings are very distinct but small, with strong radial lines from the centre; these are known as medullary rays. When these are cut obliquely across it shows beautiful marks which are known as the silver grain or felt. The colour of the wood is quite light when new cut, but turns to a brownish yellow when seasoned. The surface is hard, firm, and glossy, the timber is hard, tough, and strong, and used for all purposes where strength and durability are requisite. It is also used for the very highest class of joinery, and is also extensively used by the cabinet maker.

The Cluster-Fruited or Bay Oak is generally found more towards the **North, near Durham**; the timber is similar to the other, but of a redder tinge. The timber is more liable to warp than that from the **stalk-fruited oak.** The medullary rays are further apart, and the glossy smoothness of the grain causes it to resemble chestnut. This last has no medullary rays.

American Oak.

This is from **Canada**. The wood is of a pale, rich brown colour; it is similar to **English** oak, but not so strong or durable, the silver grain is not so fine as in our oak, and the timber is said to be wanting in durability. The trees grow more rapidly than the **English** oaks, and though straighter in grain, the wood is much more open and coarse.

Selection of Timber.

How to judge timber, either in the log, or when cut up, cannot be learned from books; though much valuable information may be derived from such a source. Practical experience will always be necessary in determining whether a specimen of timber (though of the required sort) is fit for the work under consideration or not.

In general if a log or tree has little sapwood on it, such a tree has passed maturity; as a tree ages it has less sapwood. If a tree has not attained to maturity the strongest and best wood is next the heart. Timber cut from a tree which has passed maturity will be the best next the sapwood, or furthest away from the pith, as timber when left standing too long begins to decay at the heart. If two trees of the same age and other conditions equal, be felled one in the spring, when the sap has begun to rise, and the other in winter, the timber from the latter will be superior in every respect.

Seasoning.

This is a branch that receives far too little attention, and the evils resulting therefrom are not discovered until it is too late. Bad fitting sashes, doors, open joints in the floors, skirting boards twisted and shrunk, screeching stairs, &c., all proclaim the fraud.

As a rule expense is the great bugbear, people think it will do, and as A is ten per cent. cheaper than B, A gets the contract. In order to keep a good stock of well-seasoned timber for a firm of only moderate size, it requires a great amount of capital; the interest of which adds to the cost of the timber. Instead of allowing plenty of time for natural and gradual seasoning, first by stacking in the open air, and then finishing off in the drying shed; it is put in a stove and dried far too rapidly. The result is that when the work is sent to the building it first swells, then after the house gets occupied and gradually dried, the wood shrinks and the evils named above begin to be found out; though this takes some time, they are always discovered too soon.

The seasoning should be carried on where all vegetable matter has been excluded, if any doubt exists then the ground should have a layer of asphalt spread over its surface. The foundation must be level, straight, and not in winding, or, true, as it is called in the workshop; if this part be not attended to the boards will get a permanent twist. For 1″ boards the bearers should be about 4′ apart, after the first is laid then strips of wood 1½″ by 1″ thick are placed right over the bearers, and the succeeding strips are kept plumb right up to the top; this is necessary in order to secure a solid bearing. If the stacks are to be carried a great height the width of the strips should be increased, otherwise the boards in the bottom where the strips are will be crushed. The time required for seasoning varies with different kinds of wood. 1″ boards of red or yellow pine should be in the open air twelve months and a like period in the drying shed. Oak and similar hard woods two years in the stack and one in the shed. The sheds, as a rule, are slated, the ends being built up and sides open, except where the pillars are, which, as a rule, are 10′ centre to centre, these carry the roof trusses. In general the boards are set on edge and prevented from twisting by vertical pieces. For framing, such as doors, &c., it should be tenoned and morticed together, and then left for six months to dry before it is glued up.

Felling Timber.

The trees should be felled in November, when free from sap, and after they are cut down they should lie for six or twelve months before being cut up. This improves the quality of the wood, and at the same time allows any juice or sap to escape in a gradual and natural way. Timber cut from a tree that has been treated in this manner is not so liable to split or shrink as when it has been cut up full of sap. When timber is newly cut it should not be exposed at once to either keen spring winds or a hot sun, as the sudden change is likely to produce shakes.

How to detect Sap.

In case any doubt exists as to whether a board has any sap on or not, proceed as follows:—Cut a short piece off the board, and let it be the full width; put it in the oven and dry it. After drying it take a piece off the side and an equal piece out of the centre, soak them in water for six hours, and then dry them again; if the outside contain sap it will have absorbed more water, and will be longer in drying.

Or take two pieces equal in size, one from the centre and the other from the side; dry them well, and weigh them; then steep them in water for twelve hours; take them out and weigh again, if they each absorb the same weight, it may be inferred that they are both heartwood; if one absorbs more than the other, the one that has increased most in weight is the sapwood. The above applies to good sound timber.

The following terms should be familiar to all.

Log. This is the name given to the trunk of a tree when the branches are lopped off. **Balk.** This is the name given to the log after it is roughly squared. **Flitch.** If a log be cut up the centre, or if the pieces be more than 6″ thick, they are called flitches. **Plank.** A piece of sawn timber not less than 11″ broad and from 2″ to 6″ thick. **Deal.** 9″ broad, but not more than 4″ thick. **Batten.** 7″ broad, and not more than 4″ thick. **Board** is the name given to any piece of wood any width and length, not less than ⅝″ and not more than 2″ thick. **Quartering** is the term given to any small scantling as 4″ × 2″, 4″ × 3″. The term does not apply if one of the dimensions exceeds 4½″ **Stuff** is the name given to any cut timber.

In closing this brief description of a few of the principal varieties in general use, it will be noticed that nothing is said about the leaves, brands, and such like. In the author's opinion such would have been out of place in a book for joiners, as he has to judge the timber when these have been removed. Brands are all very well in their way, for instance when a merchant has once examined a log, &c., and put the brand or mark on it, he can tell as soon as he sees the mark what class it belongs to. Brands are purely arbitrary, and may be used by any one. If a builder has been accustomed to deal with a merchant who uses brands, and he has had ample proof that the brands are a *bona fide* indication of the quality they represent, then the order may be given by naming the brands required.

SYLLABUS FROM THE CITY AND GUILDS OF LONDON INSTITUTE PROGRAMME.

CARPENTRY & JOINERY.

The Examination in the Ordinary Grade will consist of a paper of questions only.

The Examination will include questions founded on such subjects as the following:—

1. Nature and properties of the various kinds of wood used in Carpentry and Joinery, with the ports or places from which they are obtained. Methods of seasoning and preservation of timber. Strength of timber. Mode of planning and converting materials, so as to avoid waste and shrinkage, and obtain the maximum strength or stiffness.

2. Tools, their names, shapes, uses &c. Labour-saving machinery.

3. Mechanical drawing as applied to Carpentry and Joinery. Plans, elevations and sections of simple solids. Drawings (full size), showing shoulder-lines, &c., on the material before it is cut; and the various joints in Carpentry and Joinery. Setting out rods. Working drawings of panelled and framed and braced doors, door frames and casings, double hung sashes, sliding and hanging shutters, French casements, folding shutters, and boxings, rebates or linings for swing doors, &c.

4. A general knowledge of the proportion of stiles, rails, muntins, &c., in doors and windows, heights of rails in doors to suit knobs or latches, the usual sizes of doors, windows, &c., and of the kind of material and strength to be used.

5. Mouldings, their forms and names. Intersection of mouldings at different angles, also of straight and circular mouldings. Enlarging and diminishing mouldings. Lines for determining the sections of moulded bars and hip-rafters in skylights and lanterns. Method of determining the true section of raking mouldings over square or oblique plans, also when the given moulding is on the rake.

6. **Bevels.** Finding bevels for hip-rafters, jack-rafters, purlins, splayed linings, raking mouldings, and oblique work generally. Also a knowledge of the method employed to place bevel lines direct upon the work, without making a drawing of the same.

7. Newel and geometrical stairs. Proportion of riser and tread. General planning of stairs to clear windows, and other obstacles, and to obtain proper head room. Method of finding the proper position of winders and diminished fliers. General construction, and methods of support.

8. Mechanical principles. The principles required in framing roof trusses, timber partitions, trussed girders, bracing large doors, gates, &c. Drawings to scale of the same, showing the comparative strain in different parts, by means of parallelogram of forces. Fixing and striking large centres, &c.

9. Methods of strengthening beams and girders by "flitching" and "trussing" &c. How wood roof trusses are acted upon by cambering the tie beam, and the motive for cambering.

10. Joints. Mortice and tenon, the proportion tenons should bear to the thickness and width of material. The proportion of the parts of the tusk tenon, the position of mortices with regard to the neutral axis. Joints for oblique timbers, position of the shoulder with regard to the direction of the strain. Different methods of scarfing. Proper position, and kind of straps and bolts used to secure joints.

11. Hinges, various kinds of, and modes of applying them. Centre-pin joint, back-flap, rule-joints, &c. Working drawings, showing the path of different parts of the work so as to obtain clearance, &c.

12. A general knowledge of the use of weather boards, water bars, throating, &c., for external work. Particular attention should be paid to the form of joints and manner of hanging French casements and skylights.

13. Plumbing and slating. Preparing and fixing flashings, tilting pieces, forming drips, rolls, cistern heads, &c., for plumber and slater, construction of flats for lead and zinc,—also, preparing and fixing angle beads, grounds &c., for plasterer.

PROJECTIONS OF A STRAIGHT LINE, &c.

This chapter is devoted to the projection of a straight line in different positions; a couple of regular solids, and a development.

Figs. 1 to 6. Show a straight line in plan and elevation. The elevation is supposed to be projected upon a vertical plane, whilst the plan is projected upon a level or horizontal plane. For convenience this is all drawn on a level surface, the line x y, dividing the plan from the elevation.

Fig. 1. Shows a straight line in plan and elevation, the line being perpendicular; its plan is a point.

Fig. 2. Is the same line when horizontal, and square or at right angles to the vertical plane; its elevation is a point.

Fig. 3. Represents the same line when level, and parallel to the vertical plane.

Fig. 4. Shows the projections, *i.e.*, the plan and elevation of the same line, when parallel to the plane on which its elevation is drawn, and inclined 30° to the ground or horizontal plane.

Fig. 5. Represents the same line horizontal but inclined to the vertical plane. In each of the five examples the plan or elevation shows the true length of the line, this is always the case when the line is parallel to the plane on which it is projected. In Fig. 3 the line is shown full length both plan and elevation, as it is represented parallel to both planes of projection.

Fig. 6. Is the same line inclined to both planes of projection, and of course the plan and elevation are shorter than the real length of the line. This is the case with hip rafters. In the present instance the line is 2½" long and makes an angle of 30° with the horizontal, and an angle of 45° with the vertical plane.

Draw an elevation of the line inclined 30° with the ground as seen at a′ b′, then the distance a b′ measured along x y is the length in plan of a line 2½" and making an angle of 30° with the ground. Next set off a b inclined at 45° to the vertical plane, and from b drop a perpendicular to x y, meeting it in n; then a n is the length in elevation of all lines 2½" long, and inclined at 45° to the vertical plane. Take the distance a n in your compasses and with a′ as centre cut x y in m′, then a′ m′ is the required elevation. For the plan, a is the plan of a′, and from the point a in plan as centre and radius a b′, draw in the arc b′m. (which may be considered as the base of a cone, the generatix being a′ b′;) then drop a perpendicular from m′ and where this cuts the arc in m determines the plan o m′, join a to m and the plan and elevation are complete.

Let it be borne in mind that the plan of an object is obtained by dropping perpendiculars from all its corners in elevation to the horizontal plane, and joining these points, and *vice versa* for the elevation.

The principle upon which this problem depends cannot be too well understood, as it is the key to nearly all the bevels that follow.

Fig 7. Shows the projections of a rectangular block, the ends being squares.

Fig. 8. Represents the same block when the perpendicular sides are at angles of 45° with x y. These are given to show how the plan and elevation are projected, one from another.

Fig. 9. Is a solid made up of four equal equilateral triangles, called a tetrahedron. Having drawn its plan and found the intersection of its sloping sides, by bisecting each side and joining that point to the opposite angle, project the points to x y, let the one through the vertex be indefinite. Then with a as centre, and a′ c′ as radius cut the vertical line in v′ which determines the height of the tetrahedron.

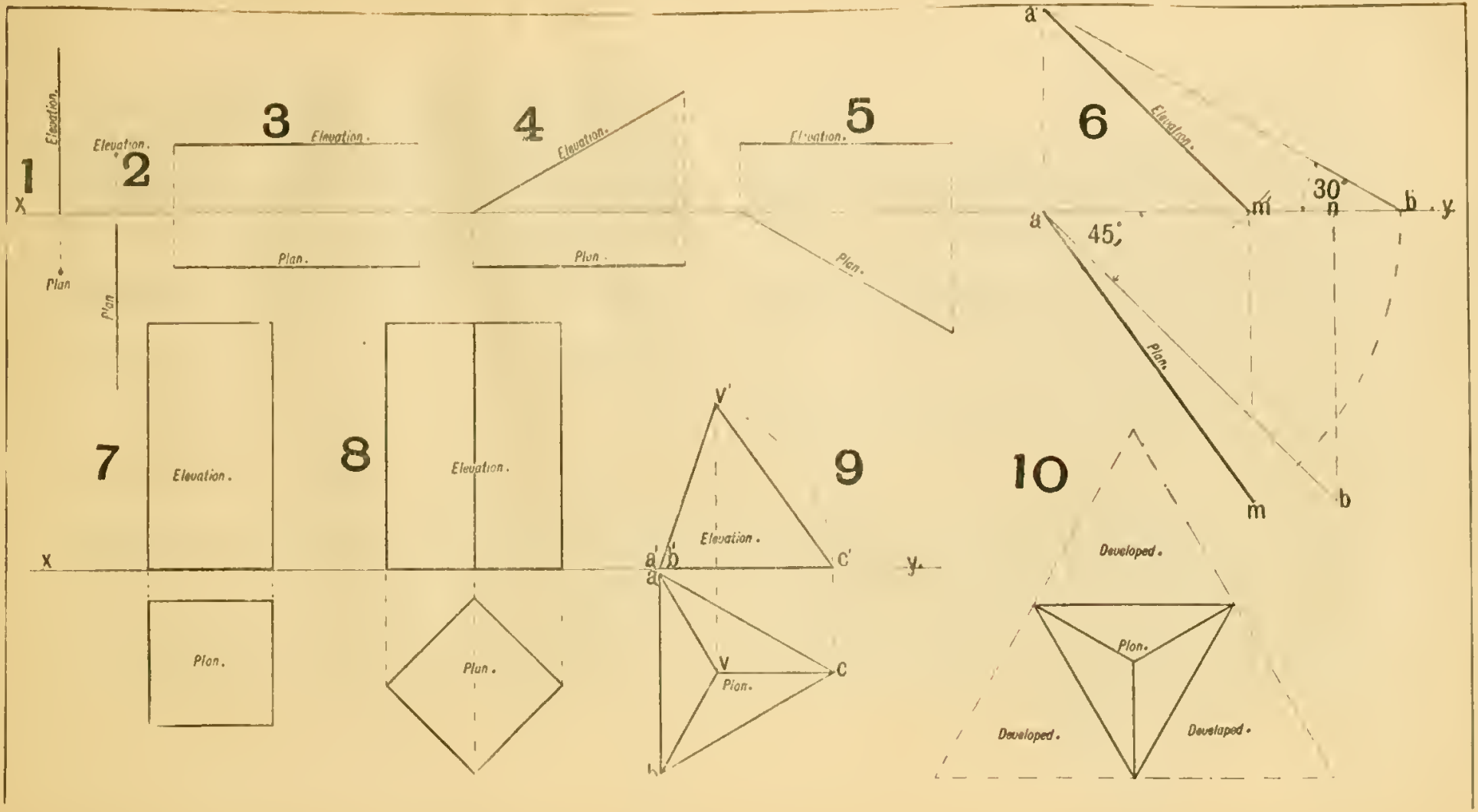
Fig. 10. Is the plan of the same, the dotted lines showing the three sides of the tetrahedron developed upon the horizontal plane.

Exercises.

1. Show the true length and inclination of the longest straight line that can be drawn in Figs. 7 or 8.

2. Draw a tetrahedron side 2"; a line bisects the plan of a slant edge and is at right angles to it in plan, let this line represent a vertical plane cutting the solid. Show the real section.

3. Draw two lines parallel 1½" apart and square to x y and passing above and below it. Draw a line 2" long below x y one end on each line; above x y draw a line 3" long being the elevation of the line just drawn. Show four different ways of determining the true length of line.


1
Elevation.
Plan.
2
Elevation.
Plan.
3
Elevation.
Plan.
4
Elevation.
Plan.
5
Elevation.
Plan.
6
a'
Elevation.
m
30°
n
b
y
a
45°
Plan.
m
b
7
Elevation.
Plan.
8
Elevation.
Plan.
9
v'
Elevation.
a' b'
c'
a
v
c
Plan.
10
Developed.
Plan.
Developed.
Developed.
x
y

ORDINARY SOLIDS.

Fig. 1. A and B, shows a plan and elevation of a rectangular block or prism, the ends being squares of ¾" side; and the long edges are inclined 30° to the h p, and 45° to the v p. Having determined the inclination as in the previous chapter, draw an auxiliary elevation a b c d shown at C. And from this, project the plan as shown at B; the plan is complete, as it never varies in shape when kept on one edge and at the same inclination to the horizontal plane.

To draw the elevation, take projectors from each of the points in plan, and set up the heights upon them from x y, e' a, f' b, c h'; that d and g it will be seen are in the horizontal plane, *i.e.*, on the ground, join the joints b" f" &c., and the elevation is complete. The dotted lines show the position of edges that are not seen when in this special position.

These require to be studied by the student, and it may be remarked that all outside lines are full. In the present instance it will be observed that the edge from a" cannot be seen, therefore lines from a" to their respective corners, cannot be seen, as a" b", a" e", and a" d"; further—the end towards you in plan is shown full in elevation.

Fig. 2. a, b, c, d, v, shows the plan of a square pyramid before being cut, the axis being vertical; the prism is cut by a plane y z, and its plan projected from it; b, c, a", d"; these points are determined by projectors from the points on y z. The apex in this first or auxiliary elevation is cut off to allow room for the next figure. Project the elevation v' a"' d"' b" c". These heights are taken from the original elevation, b" and c" being taken as a line of level, then all the other heights are measured from this The side v d" c is developed and seen on the right at v' m o, the line m o being dotted. Having determined the length of the lines c v, d" v, by the method already explained, m n is made equal to b c, then the triangle v' m n is true the shape of one side; to determine the dotted line m o, which is shown in plan by c' d" and in elevation by c" d"', turn one of these parallel to the horizontal plane, and its true length will be obtained.

Fig. 3. Shows a similar pyramid cut by a plane w x, which is parallel to y z, the difference being that the cutting plane is at right angles to a diagonal of the base. Having projected the plan as in the last, draw in the elevation, *i.e*, erect perpendiculars and on these set off the respective heights, and join the points v", a', b', c', and d'; these, being joined, complete the elevation. To determine the plan of the diagonal b d when cut, draw the horizontal line d o, this gives half the diameter or half the required diagonal, which being set off each way from v, determines the length of diagonal in plan, join the points and plan is complete. See etched part.

The triangle v"' c" d" shows the development of one side, obtained as before described, *i.e.*, by finding the length of each side and forming the triangle.

Fig, 1. Shows how an ordinary hip rafter would be projected in plan and elevation.

Figs. 2 and 3. Show how square turrets are projected upon common roofs.

Fig. 2 Has its sides parallel and at right-angles to the ridge.

Fig. 3. Has its diagonals one parallel to the ridge, the other square.

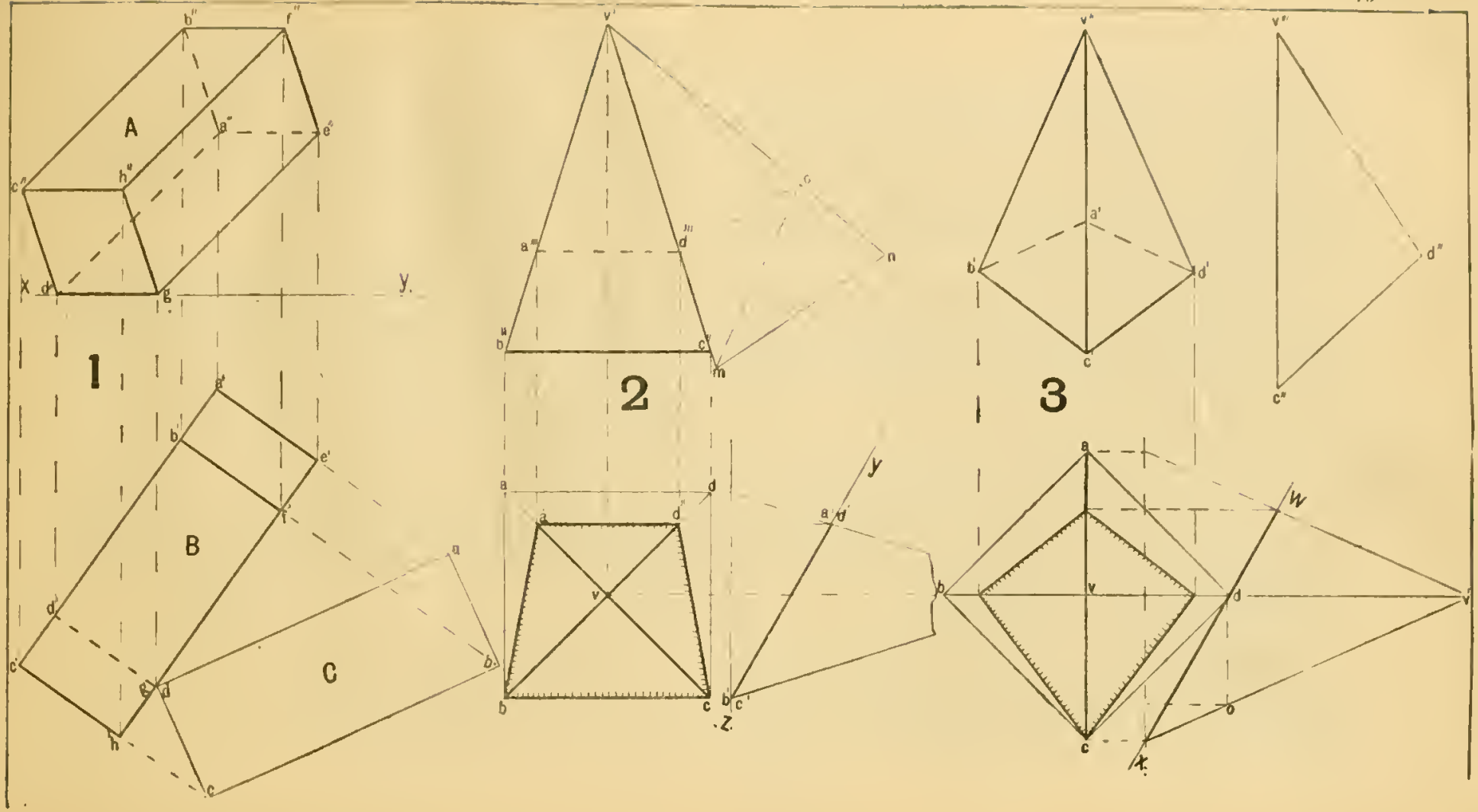
Exercises.

1. Let the prism in Fig. 1 stand perpendicularly upon the horizontal plane, its sides being parallel and at right angles to x y, or the vertical plane; if cut by a plane passing through three of its corners at heights of 1", 1½" and 2¼" above the ground. Determine the true shape of the section.

2. Determine the true shape of the least side in Fig. 2, also the true shape of the base after being cut by the plane y z.

3. Determine the real length of the line v" a' seen in elevation Fig. 3, also the true shape of the two small sides, and the true shape of the base.

4. Show the inclination to the ground, the line g", e" Fig. 1.


A
B
C
1
2
3
x
y
z
w
k

CIRCLE and ELLIPSES.

Fig. 1. Plan and elevation of a circle are shown, the surface of the circle being parallel to the plane on which its elevation is drawn; the plan is represented by a straight line equal to the diameter, and its elevation shows the true circle.

When a circle is given to find the centre from which it has been drawn, draw a cord as a b, and bisect it by a line n o perpendicular to a b, draw a second cord c d and bisect it by the line m o, if n o and m o be produced they will meet in a point, the point where they meet is the centre. This rule applies when the opening and rise of a door, or window are given, to determine the length of radius.

Fig. 2. Shows the same circle when perpendicular, and inclined to the vertical plane; divide the circumference into any number of equal parts; in this it is divided into eight. The extremities of the diameters making four, then the spaces between are bisected, from the circle in elevation project horizontal lines, and from the corresponding points in plan erect perpendiculars, where these meet determines points in the elevation, draw the curve passing through the points and the elevation is complete. The figure is an ellipse.

Fig. 3. Three points, a, b, d are given, required the centre of a circle to pass through them. Join a b and bisect it by a line c d, join a d, and bisect it by a line p q, then produce these, and where they meet in o is the centre. This has been made to appear as an opening for a door, &c.

When the opening a b and the rise c d are given, to determine the length of radius by figures, multiply half the opening by itself, and divide it by the given rise (c d), to the result thus obtained add the given height, then this last divided by two gives the necessary radius. Care must be taken to multiply feet by feet, &c., *i. e.*, to have both in the same name.

Fig. 4. Shows how to determine points in the circumference of a circle, when the cord or opening a b and the rise c d are given; the latter being so small compared with the former that it cannot be described with an ordinary rod, owing to the length of radius. Join a b and a d, and make the angle d a e, a right-angle, draw d e parallel to a c, divide a c and d e into the same number of equal parts, and join the points 1 to 1 &c. Next divide a o into the same number of equal parts, and from points 1 and 2 join to d, where these cut the first lines 1 1, &c., determine points in the arc. Having found a few points in this manner draw the curve through them; any number of points may be taken according to the size or accuracy required.

Fig. 5. Shows a semi-ellipse, a b being the major and c d the minor axis. The method shown is as follows, take any straight edge and mark from one end a distance equal to half the major axis, a c, and a second one c d equal to half the minor axis, place these two points one on each diameter and move the staff along, first one side and then the other, marking points at the end of the rod as it is being shifted, these are points in the curve of the ellipse. Observe, the two points on the rod must be kept one on each diameter whilst the rod is moved from side to side.

Fig. 6. Shows how points may be found by arcs of circles. Given a b the major axis, and c d the minor axis, determine the foci f and f, with half the major axis as radius, and from c and d as centres describe arcs cutting the line a b in points f f; that is to say the distance from c to f or d to f, is equal to half the major axis. From f towards the centre mark a few spaces as 1, 2, &c. Then take the distance from a to 1 in your compasses, and from f and f as centres describe arcs of circles, take b to 1 in your compasses and from f and f as centres describe arcs cutting those already drawn in points 1. 1. 1. and 1 which determine four points in the curve, repeat the process and any number of points may be determined in the curve of the ellipse. These last two methods apply when the axes are at right angles.

Fig. 7. Shows how points may be determined in the curve of the ellipse when the axes are not at right angles to each other. Divide the semi-major axis into any number of equal parts as 1, 2 and 3, join these points to p, and make the line at the end equal and parallel to the axis, and divide this line at the end into the same number of spaces as the other, join those to the opposite end of the minor axis from p, and where they cut the lines from p through 1, 2 and 3 determine points in the curve of the ellipse.

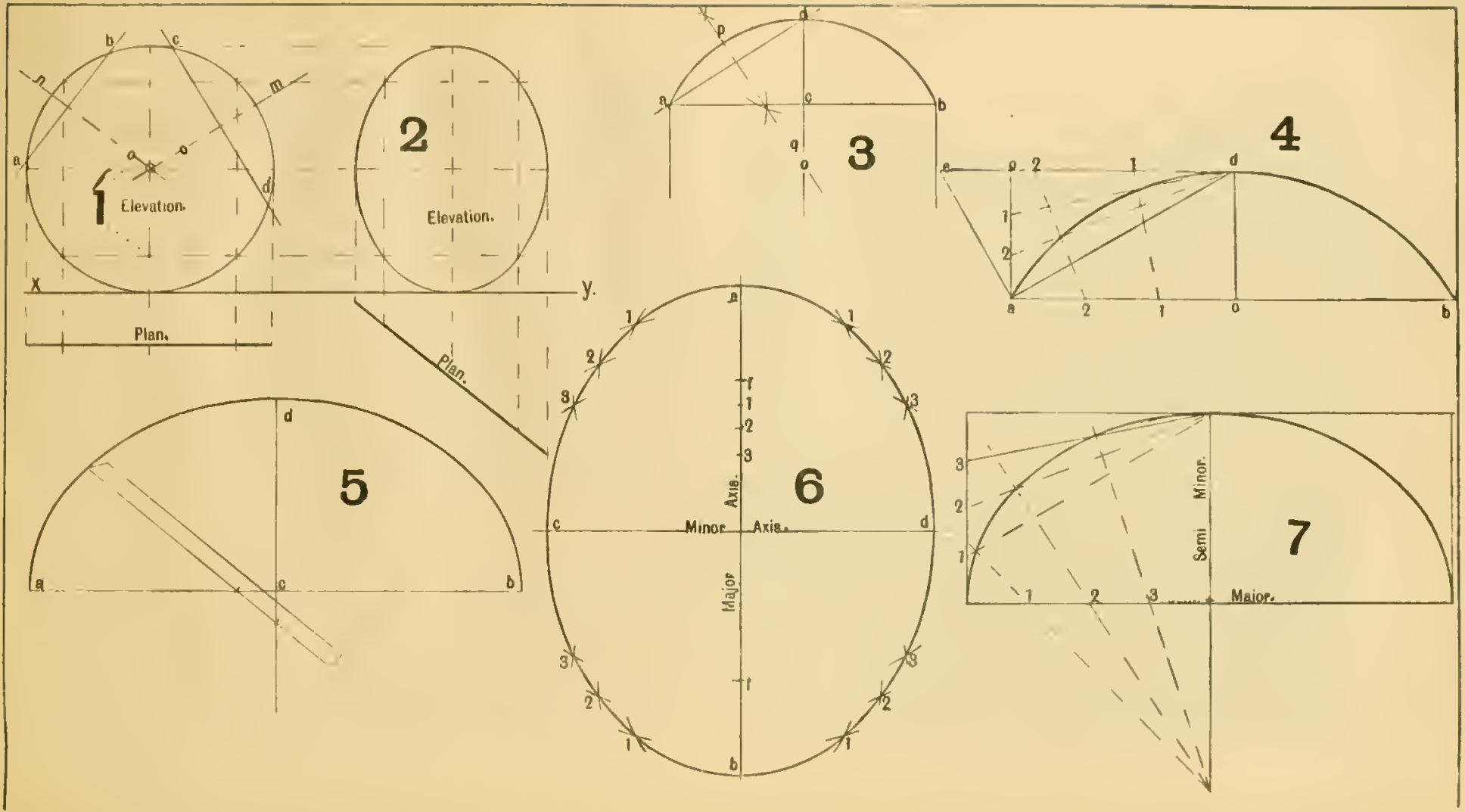
Exercises.

1. Determine points in the arc of a semi-circle by intersecting lines.

2. The opening of a segmental arch is 8′ the rise 12″. Determine the length of radius (a) by figures (b), geometrically.

3. Draw the plan and elevation of a square 2″ side, when its surface is inclined 30° to the h p and 40° to the vertical plane.

4. Given a rhomboid its long sides 4″, and its short sides 2½″, the acute angles being 45°. Draw the inscribed ellipse.


1
Elevation.
2
Elevation.
Plan.
Plan.
X
y.
3
4
5
6
Major Axis.
Minor Axis.
7
Semi Minor.
Major.

ELLIPSE AND CONE.

Fig. 1. Given an ellipse, to draw a normal, tangent, and a line parallel to the curve.

Let the two conjugate diameters be at right angles to each other, and the curve of the ellipse drawn, from any point as a, to draw a normal, *i.e.*, a line perpendicular to the curve at the given point. Determine the foci of the ellipse as described in the last chapter, then from the point a draw lines to f and f, and bisect the angles so formed; the line that bisects the angle is at right-angles to the curve at the point a. At the point h a normal is shown which is obtained as described.

To draw a tangent as m n to the curve of an ellipse shown at o, determine the normal at o as already described, and draw m n at right-angles to it.

To draw a line parallel to the curve of an ellipse, shown at c d; produce the normals, and set off along them a c, h d, the required distances, and draw in the curve through the points.

The normals represent the joint-lines in semi-elliptical arches, &c.; any amount of points may be taken according to the number of joints required. The line parallel to the curve is necessary to show the different members in moulds for elliptical panels, &c.

Fig. 2. Shows a plan and elevation of a cone standing upon an inclined plane seen at x y. (Fig. 2a.) To draw this, having given the pitch x y, the base and height of the cone, draw in the plan, *i.e.*, the full circle, also a full elevation shown passing through x y. Draw horizontal sections at any points beginning at 2 (because 1 is the finish on x y), draw this line and where it cuts x y, find the real length through the cone at that point, by assuming it to be cut by a plane. With the centre of the cone on that line and a radius equal to half the diameter, draw the semi-circle, as shown by the dotted lines, and where a perpendicular from x y cuts the arc, it is half the distance through at that point. Then in plan set off the distance on each side of the axis, and the points so marked show two points in the curve of the plan. The points are shown projected into plan and elevation one from another. Take sections 3, 4, and 5, treat these in exactly the same way, the lengths to be set off on each side of the axis in plan, are shown by thick lines from x y to the semi-circles and marked 2, 3, 4, and 5; having obtained a few points in plan, sketch in the curve through them.

To draw the elevation; erect a perpendicular through the axis, and equal in length to the axis; set off on any vertical line spaces equal to those on the section 1, 2, 3, 4, 5, 6, and 7, draw the horizontal lines from these points, and erect perpendiculars from the corresponding points in plan; where these meet, the points in the curve of the elevation are shown.

This is the case, when conical turrets are shown on ordinary roofs.

Fig. 3. Shows the development of half the cone when cut.

Divide the base into a number of parts 1, 2, 3, &c. (explained for Fig. 1a) then find the lengths of these lines and set them along their respective lines as 1, 2, 3, 4, &c., the longest line being equal to the slant edge or generatrix of the cone, and the short one from where the other cuts x y to the apex. To find the length of the other lines, draw from the plan into the section, to cut the line x y, and draw a horizontal line to cut the side, then measure from this point to the apex, and set it on the development, treat the points from 1 to 9 in this way and the development is complete.

Fig. 1a. Is the elevation, 1a′ the plan, and 1a″ the development of a cone. Having drawn a plan and elevation from any point with a radius equal to the slant side or generatrix of the cone, describe an arc of a circle 1a″, and along this arc set off the same number of equal spaces to those in 1a′ from 1 to 8, then from the centre to the points in the arc draw the line 1, 1, and the development is complete.

This may easily be proved by taking a piece of paper and cutting it to cover a cone.

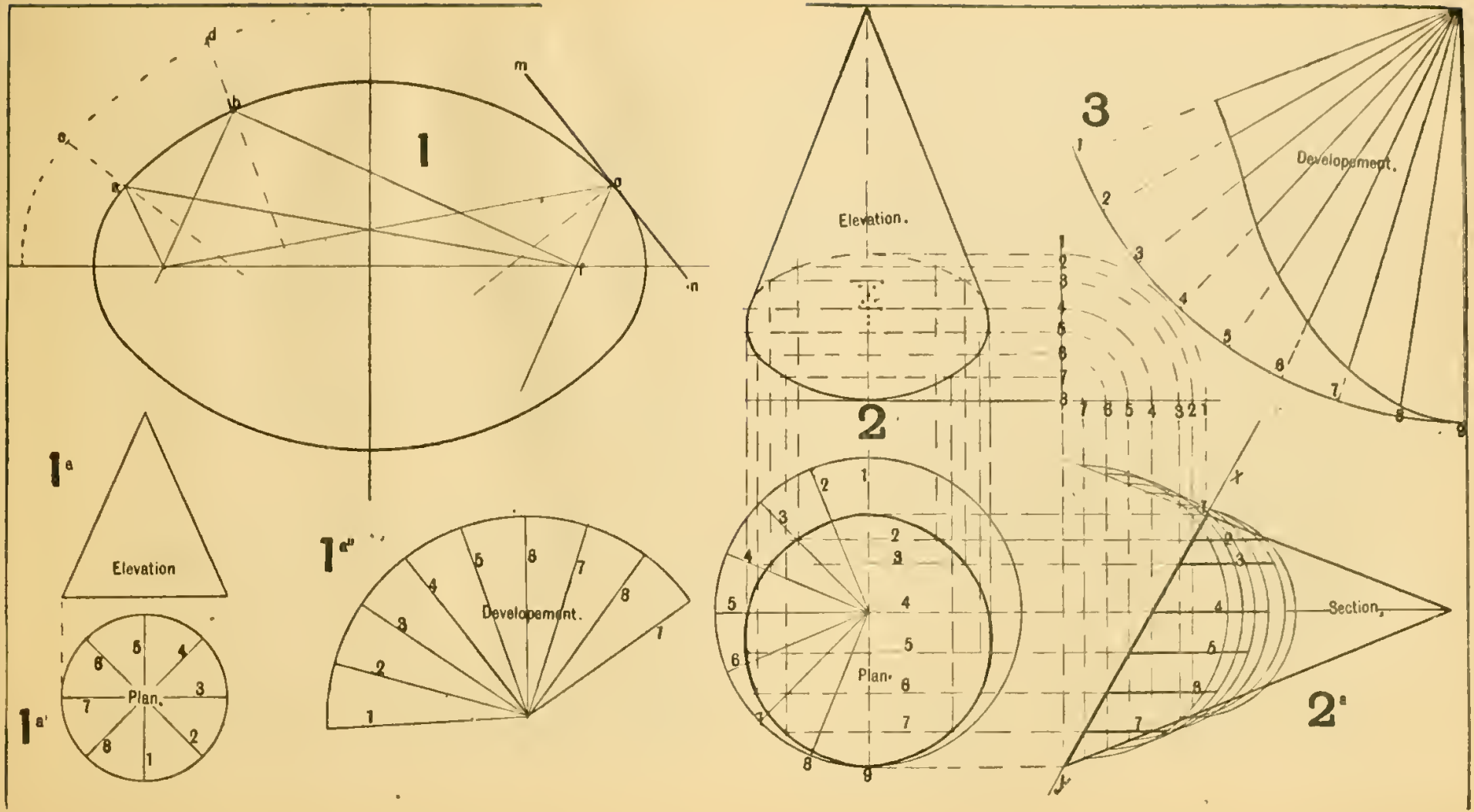
Exercises.

1. If a cone be cut by a vertical plane parallel to the axis, the section is an hyperbola, draw such a section, axis of cone 3″ base 2½″ diameter; when cut ·25″ from the centre.

2. If a cone be cut by a plane parallel to a slant side or generatrix, the section is a parabola, draw such a section ·5″ from one side. Size of cone as in Fig. 1.

3. Given a rectangle 3″ × 2″ draw the circumscribing ellipse.

4. Show the true shape of the base of the cone after being cut, see Fig. 2 on the plate.


1
1a
Elevation
1a'
Plan.
1a''
Developement.
Elevation.
2
Plan.
3
Developement.
2a
Section.

INTERSECTION OF BOTH STRAIGHT AND CURVED SURFACES.

Fig. 1. a b c v. Represents the plan of a triangular pyramid, its sides forming equilateral triangles; the special name for this solid is tetrahedron. This has been repeated to show the true angle between two sides, which angle is shown by the triangle x o' y, to determine the height of the vertex, produce a v to n, draw v v' parallel to b c, with n as centre and n a as radius draw the arc a v', then v v' is the height.

To determine the true angle, it is necessary to take a section at right angles to the plan of one edge and at right angles to the same edge in elevation, x y is the line square to the edge, b v'' is the true length of the same edge, v o is square to the edge in elevation, or at right angles to the slant edge; from v as centre and with v o as radius, determine o' on b v, then join o' to x and y and the profile, dihedral, or true angle between the two planes is shown. This angle is known in the workshops as the backing of a hip.

It must be clearly understood that b v'' is the true length of the edge b v (seen in plan), and that v v'' is equal in height to v v'.

Fig. 2. Shows the plan and elevation of an irregular triangular pyramid, when its sides are inclined at various angles.

Fig. 3. Let the sides be inclined at 30°, 45°, and 60°, draw two parallel lines, and from o set off a line at 30°, cutting the other line at c, then o c' is the plan of the line or side at 30°. From o draw the line o b at 45°, then o b' is the plan of the side at 45°. From o draw o a at 60°, the line o a' is the plan of the side at 60°. From the sides a b c, Fig. 2, draw arcs of circles with radius equal to the lines o a', o b', and o c', draw the dotted lines tangental to these and parallel to the sides, and from where they meet to the angular points is the plan of the intersection of two sides, produce these intersecting lines towards the centre, and where they meet in v is the apex of the solid.

To determine its height, draw the line v o at right angles to b, then v o is the plan of a line at 30°. Project the elevation as shown, and the plan and elevation are complete.

Fig. 4. a b c d, Represents the plan of a semi-cylinder, e f g h is the plan of a second at right angles to the first.

Fig. 5. Shows the end elevation or section of a d and b c.

Fig. 6. Shows the end elevation or section of e f and g h. The diagonals W X and Y Z are the plans of the intersections. It will be seen that the end of the first cylinder is a semicircle, and the section or end view of the second an ellipse, which has been projected from the first. To draw this section, take any number of perpendiculars through the first section, and let these be projected into the plan to the intersection; from those points and from the springing line m n, set up the same heights as those from k l, only one point a 3, a' 3', a'' 3'', being marked in its various positions. The other points follow exactly the same order, and having obtained a few heights, marking them off upon their various perpendiculars, the curve is traced through the points from m to n.

Fig. 7. Is the elevation of the intersection Y Z, and is projected upon a plane parallel to the line of intersection. The various heights being the same as in the first elevation; the only one marked being 3 a.

The profile angle in Fig. 1 is necessary when hips or valleys of a roof have to be backed, *i.e.*, when half of the thickness may lie in the planes of the roof, one half lying in the side, and the other in the end.

The section being taken at right-angles to both the edge and side of the hip.

Fig. 2. Shows how to determine the plans of the hips in a roof when the sides and ends are sloped at various angles, this method applies when the plan is a triangle, square, rectangle, rhomboid, &c.

Fig. 3. The plan, section, &c., of this would be required for the vaults of groined arches. The end views and Fig. 7 would represent the shape of the various centres required.

Exercises.

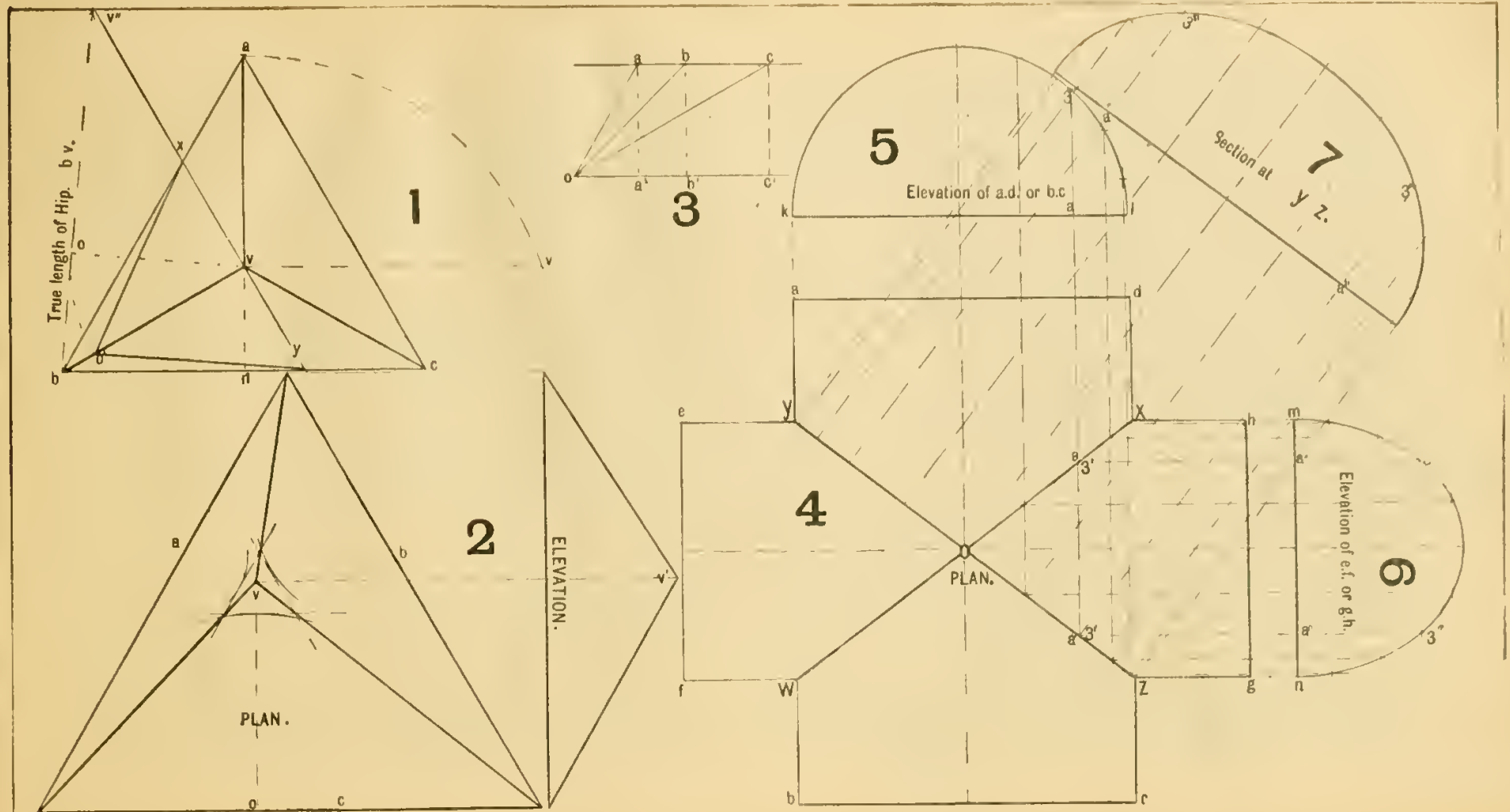
Let Fig. 1 be cut by a plane x y which is perpendicular, show the true shape of the section.

2. Show the real angle between the two planes a and b, Fig. 2.

3. Let the intersection of the cylinders, Fig. 3, represent the plan of the valleys of roofs, one inclined 30°, determine the true shape of the valley rafter.

4. Show the shape of the covering for one of the surfaces Fig. 3, as b c, W o Z.

Hint for Fig. 3. Take a line square to the plan of the valley you select, and determine the true length of the intersection, then a line perpendicular to the intersection will show the height of the triangle, turn this into the plan upon the line of intersection, and join to the two points where the line at right-angles cuts the sides of the roof (on the wall plate) or at its base; if the cut be where it does not intersect the necessary sides, then produce the sides until they are cut, and join to the first-points on the intersection.


1
True length of Hip. b v.
2
PLAN.
ELEVATION.
3
4
PLAN.
5
Elevation of a.d. or b.c
6
Elevation of e.f. or g.h.
7
Section at y z.

BEVELS FOR OBLIQUE WORK.

Having in previous chapters explained the projections of a straight line when inclined to both planes of projection, likewise some of the ordinary solids, those who have mastered the foregoing will find no difficulty in applying these principles to practice, in the determining of bevels for oblique work in general.

The present chapter is devoted to a few cuts or bevels, showing that the principle of sound projection applies to a complex as well as a simple case.

Fig. 1. Shows a vertical post and a stay or strut, in each of these a right section is a square, the post having its sides at right-angles and parallel to the vertical plane. The stay is inclined to the ground or x y, at an angle of 60°, having its sides parallel to the plane on which its elevation is drawn; the true length, and correct bevels are shown in elevation. The bevel for the top is marked a a, and the bottom is marked b b.

Fig. 2. Shows what the result will be when a similar post has a stay cut against it, the sides or faces of the stay being at 45°, to the vertical plane.

Draw in the line a b to the inclination required, and upon this line draw a section of the stay as m n o p, to get the necessary angular points; draw lines through these points parallel to the first and the elevation is complete. The last edges are shown by the lines c d and e f.

Project the plan from the elevation and make the width equal to that shown in elevation, project b c f, and join to their respective projections a b, c d, e f, and the other side parallel and equal to c d, and the plan and elevation are complete. To determine the necessary bevels, the stay being projected upon a plane parallel to its edges, those edges are shown full length upon the elevation. The line a b represents the full length of the longest or top edge, d c represents the full length of the two centre edges, and e f shows the true length of the shortest edge.

Having the true length of the edges, develope the sides; turn out the side m n as shown, and project it to the points marked y and x, from a draw a y at right-angles to a b, then draw from y to d and the necessary bevel is obtained. The bevel for the underside is the same, and if necessary may be obtained in the same way. For the bottom bevel, draw a line from b perpendicular to a b, and where this cuts the developed edge x y in x, draw from c to x and the required bevel is obtained. The bevel from c to f is the same, and obtained in the same manner.

Fig. 3. Shows the same post and stay, both the sides of the stay and post making angles other than 90° with the vertical plane. In this it is most convenient to draw the plan, and leave points o and 4 to be determined from the elevation; draw in the two lines 1 2, 5 6, in elevation, to determine where the line 3 4 finishes in elevation, from the point 3 in plan, erect a line perpendicular, and where this perpendicular and the centre line 3 4 meet in point 3, is the elevation of that point, join 1 to 3 and 3 to 5, and the elevation of the post and stay is finished. All the edges are seen full length in elevation. To finish the plan, the points o 2 and 4 are determined from the elevation and joined, which completes the plan.

To determine the bevels for the top, develope the side and draw the line from 1 to 7 square to the edge 1, 2 draw from 3 to 7 and the bevel for the top sides is obtained, for the bevel on the bottom side, develope the underside, and draw a line from point 5 a line to cut the developed edge in 8, join 3 and 8 and the necessary bevel is shown. The bevel for the bottom end is obtained as described in Fig. 2, and need not be repeated. Both post and stay are exaggerated to show the bevels.

In these as well as succeeding bevels they have been obtained by determining the true length of each edge, and then developing the sides.

When an edge is not seen full length in plan or elevation, then a plan or elevation must be drawn showing the true length by projecting or turning it upon a plane parallel to itself.

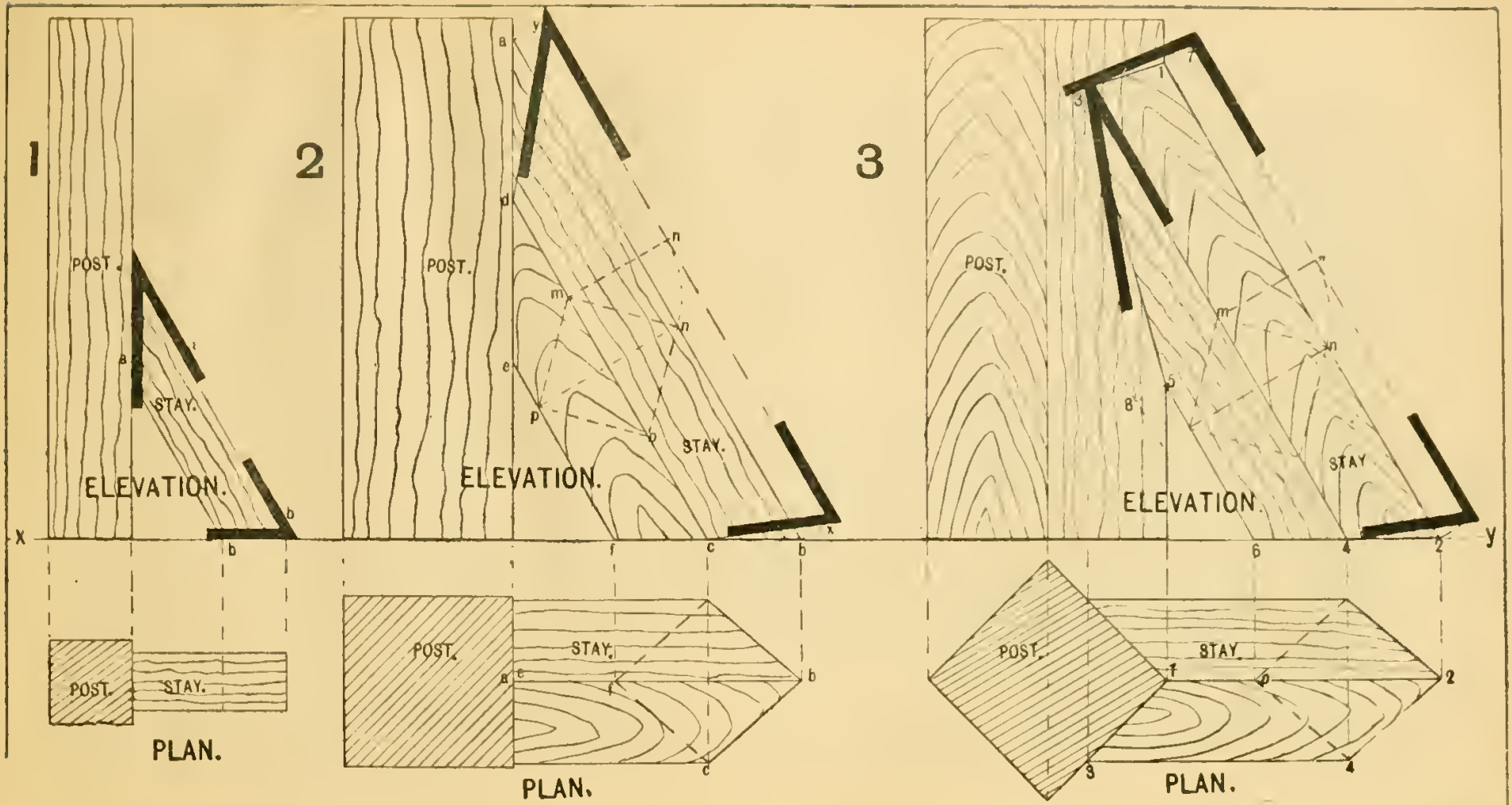
Exercises.

1. Explain why the bevels for the stay to the post in Fig. 1, show the true bevels in elevation.

2. If the stay in Fig. 2 be let into the post at its top end. Show the true shape of the aperture, or hole made in the post.

3. In Fig. 3, develope the two sides of the post, showing the portion covered by the stay.

4. Arrange a triangular post and stay, similar to Fig. 3, *i.e.*, the true section of each being an equilateral triangle. The stay to be at an angle of 45° and shown in plan by three straight lines, forming two equal spaces, and cutting against an angle of the post, scale, &c., at pleasure.


1
POST.
STAY.
ELEVATION.
X
b
POST.
STAY.
PLAN.
2
POST.
STAY.
ELEVATION.
y
x
f
c
b
POST.
STAY.
PLAN.
3
POST.
STAY
ELEVATION.
y
6
4
2
POST.
STAY.
PLAN.

SPLAYED WINDOW LININGS.

The object of splayed jambs to a window, is to allow the light to be thrown more to the sides or up against the ceiling, when it is not possible to get the window wide enough, or as close to the ceiling as necessary; and in basements it may even be necessary to bevel the window bottom, in order to throw the light as near the wall as possible.

In these cases the best thing to do is to cut off the angle, this is known as splaying the jamb, &c. When the jamb is finished in plaster or cement no bevels are necessary, as the plasterer runs the jambs and soffit to meet, forming the necessary angles; if wood has to be used then they may be framed and moulded, or plain as shown in the figures.

Fig. 1. Shows a plan and front elevation of a pair of plain splayed window linings, the frame is a solid one, no moulds or chamfers are shown, in order that the bevels may be shown as clearly as possible.

Fig. 2. Is a vertical section through the same.

Draw the plan, and project the elevation from the same. Next draw the vertical section and complete the front elevation. On examining the drawing it will be clear that the full length of the linings are shown in elevation at a d, on the left, and b c on the right, because those edges are projected upon a plane parallel to the front and back edge respectively.

The full length of each edge being known, the short edge from a to the window bottom, and the front edge to the same level, also the width of the splay m n, set off the true width of m n, see plan, shown developed by the lines a n, and d′ m, draw a horizontal line from d to cut m d′ produced, then from d′ to a shows the required bevel.

The casing at the top, shown in elevation a b c d is the soffit, and this like the jamb on the slope or cant, does not show the full width, but the true length of the front edge is seen from d to c, and the full length of the short side where it is grooved into the frame at a b, then it only requires to be developed as shown, make o p equal to the full width of the soffit, (see the section from c′ to the frame)and produce the line both ways, from c and d erect perpendiculars to cut the last line, then from a and b draw the lines a d″, b c″ and the true shape of the soffit is determined.

When the jamb and soffit are both splayed at the same angle, it is not necessary to find bevels separately, as they have the same bevels if they are canted alike. The above construction is necessary when soffit and jambs are not splayed alike.

The window bottom projects to receive an architrave or mould.

Fig. 3. Shows a plan of one corner, 3a shows part section through the top edge of one of the pieces to be mitred. Draw the plan as seen at a b e f; e f being the mitre line in plan.

To find the true mitre, let the points e f be the long and short corners on the edge, then make c d equal to e′ f Fig. 3a. Draw e e″ perpendicular to a e join e′ to f, and the mitre line is determined. This applies when the edge is square to the side, if the edge had been bevelled off as shown at Fig. 1 on the front edge of the splayed casinge, then an ordinary mitre at 45° would have been all that was necessary.

Fig. 4. A and B. A represents a section through the nosing of a horizontal window bottom, and B shows the true shape of the splayed jamb-lining, so that the two would mitre together at the front edge. This arrangement is used when the woodwork is not allowed to project in front of the plaster, a small scotia being taken out of the plaster to make a finish between the plaster and the wooden linings.

Draw a section of the window bottom as shown at A, also the required bevel for the side as shown at B, divide the nosing at A into any number of parts, 1, 2, 3, &c., as shown by the lines both cross and length-wise, then divide the jamb the same, and erect perpendiculars until they cut the corresponding lines in B, the intersection of these lines determines points in the curve for the jamb edge.

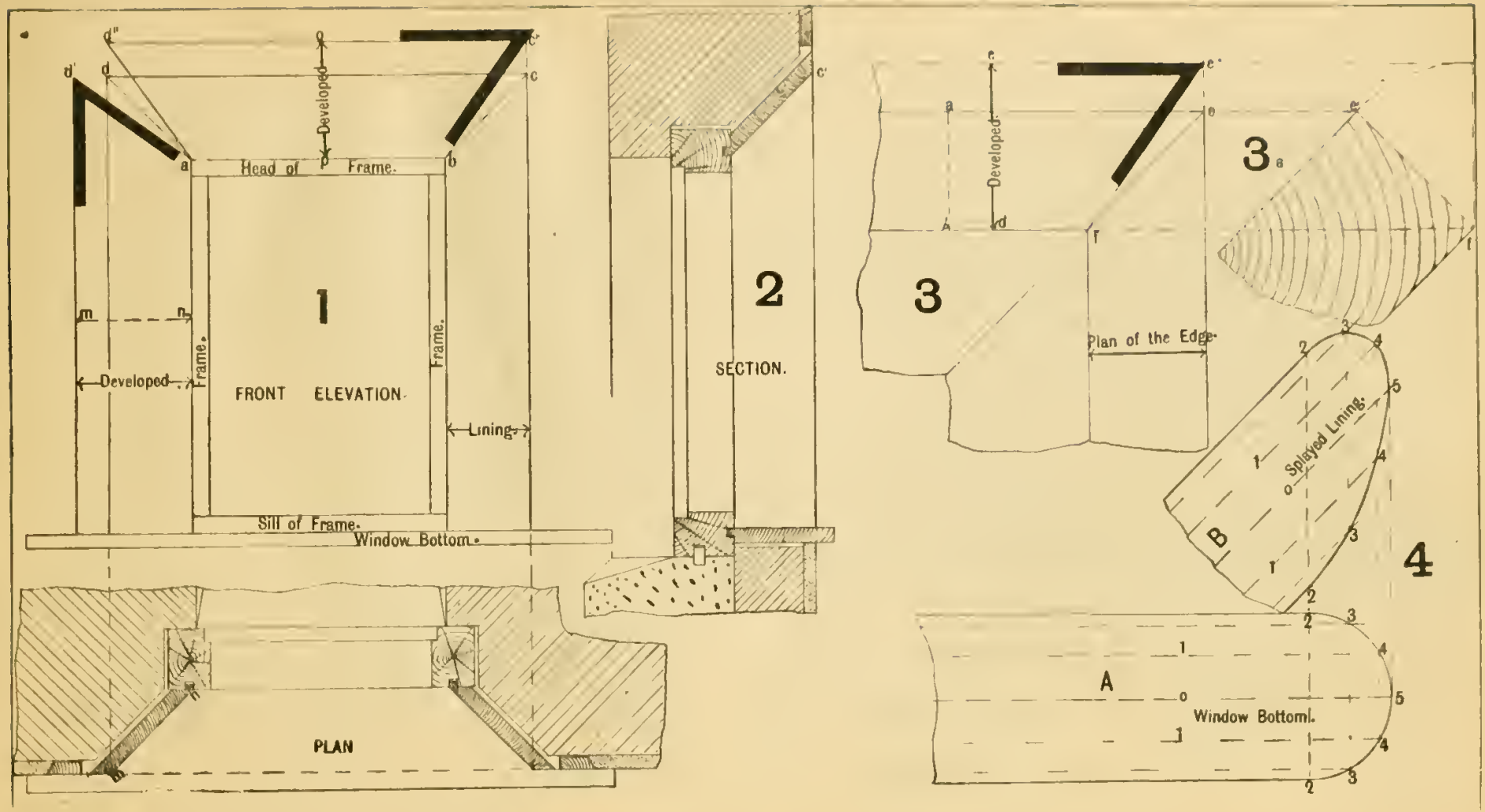
Exercises.

1. Let the soffit be inclined at 60° to the horizontal plane, and the jambs at 45°, to the window frame. Show the true shape of the front edge of the soffit, similar to the edge of the jamb, Fig. 4.
2. If the soffit be at 60°, and jambs 45°, show both side and edge cuts for soffit and jambs.

Note. The edge cuts are to be applied when the timber is square at the edge, see Fig. 3, 3a.

3. Let the plan of the angle be 60°, see Fig. 3, the two sides sloping at 45°. Show both side bevels and mitre cut for such an angle; also if one side be nailed over the other give the edge bevel.
4. Draw the plan of an hexagonal box, sides inclined at 45°, show bevels for side and edge, for mitreing, and also for nailing one over the other.

The bevels explained in Fig. 1, apply to the angles for a knife box, when the sides and ends are inclined; and to any ordinary splayed work.


Developed.
Head of Frame.
1
FRONT ELEVATION.
Developed.
Frame.
Frame.
Lining.
Sill of Frame.
Window Bottom.
PLAN
2
SECTION.
Developed.
3
Plan of the Edge.
3a
Splayed Lining.
4
A
B
Window Bottom.

CUTS FOR OBLIQUE WORK.

Fig. 1. Shows a **plan elevation** and **section**, to a small scale, of the jamb linings given on the last page; this has been repeated to show the edge cuts for the soffit and jamb linings.

To obtain the necessary, or true angles (the bevels to be applied before the edges are canted), draw **enlarged sections** as shown at B, S and T.

To determine the edge cut for the top of the jamb to fit under the soffit, draw the **enlarged section through the jamb** as shown at B, also the **enlarged section through the soffit**, as shown at T. *It is clear that the head or top end of the jamb is cut off by the soffit; this is a plane inclined 60°.*

Having drawn the **enlarged sections** of the **jamb** and **soffit**, take a line (as A E) square across the jamb.

This is to represent the timber whilst the edges are square.

Draw from A to a, and from E to e. *This is an imaginary elevation of the edge when cut off at* A E; *a and e show the extreme lengths of the two arrises where they terminate under the soffit.* **Develope the edge** from e to e', and the required bevel is shown at B.

To show the edge cut of the soffit, *i.e.* when it is cut against the jamb, as shown at the top left hand corner in elevation. Draw a part of the **soffit** as shown at S. The soffit is cut to fit the jamb which is inclined 45°.

The **Jamb** B that was used for the other may be used for this. Suppose the edge to be square as shown at C O, project these to cut the plan of the jamb lining at o' and o', develope the edge, from c' to c'', and the angle R shows the required edge-cut.

In general the soffit runs over the jambs, the top ends being trenched into the soffit.

Fig. 2. Shows a **plan** and **elevation** of a small box with canted sides, the pitch being 45°.

The **plan** and **elevation** are projected in the usual way; the side to the left is shown lapping over the other two, and that on the right is mitred at the angles.

One of the four pieces is **developed, to show the side or flat cuts**; on the opposite side the edge is developed to show the **mitre cut.**

Note. When the edges are square and the pitch 45°, the side and mitre cuts are the same. The method shown, answers for any pitch.

To obtain the bevel for the **edge-cut**, so that one side may lap over the other, as is the case when the corners of a knife box are dovetailed together. Draw the **enlarged section through one side**, and **part plan** of the corner. *The drawing shows that the edges are square and the arrises level.* Draw a horizontal line from the point 1 in the **enlarged section**, and from the point where this cuts out at 2, drop a perpendicular to the corresponding point 2' in **plan**; join 2' to the edge on the mitre line, and the etched portion shows the cross grain. Develope the edge, by drawing from 2' to 2'' and the required bevel is shown by the **angle** M.

Fig. 3. Shows the **plan** and **elevation** of a trisngular box, one side lapped over the other two, and one corner mitred.

The projections of the box and the bevels for the cuts are obtained in the same manner as those for Fig. 2. See **enlarged section, part plan,** and **developed edge.**

Fig. 4. Shows part **plan** and **elevation** of a hexagonal box, one side lapped over two of the others, and one of the six sides **developed to show the side cut.**

The projection of the **plan**, &c., is obtained similar to Fig. 2, and need not be repeated.

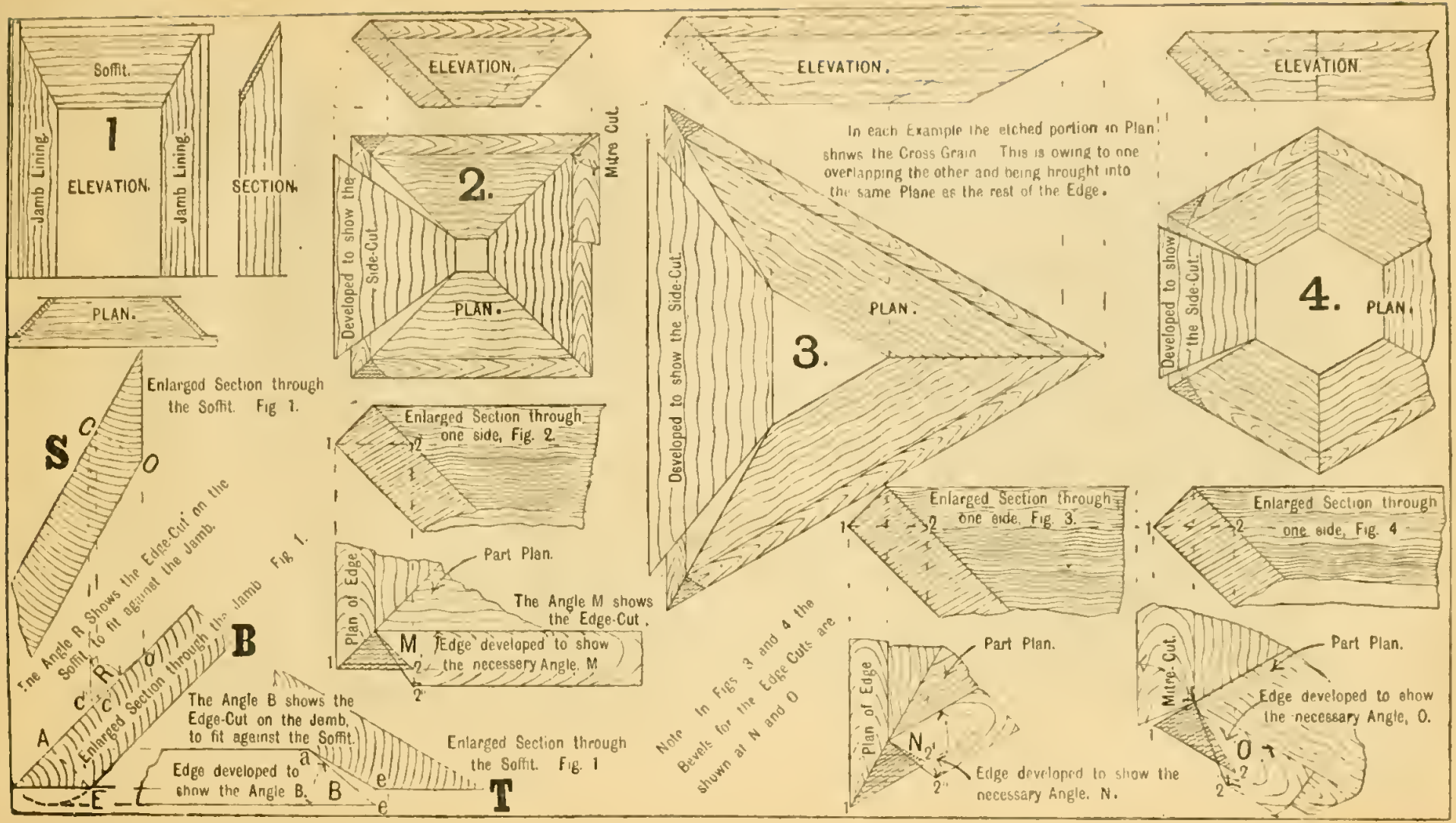
For the necessary bevels, see **enlarged section through one side, part plan, mitre-cut,** and **developed edge.**

No bottoms are shown, these not being necessary to find the bevels.

The **sides developed** are not lettered, as this part will be understood.

It will be seen on looking at the plan of any of the boxes, that the length of each piece, both edge and side is shown; hence when a correct plan is obtained, the required bevels may be found by developing the edge or side, as explained in the last chapter.

In all the examples for determining bevels, the student is earnestly requested to make models.


Soffit.
1
ELEVATION.
Jamb Lining.
Jamb Lining.
SECTION.
PLAN.
ELEVATION.
2.
Mitre Cut.
Developed to show the Side-Cut.
PLAN.
ELEVATION.
In each Example the etched portion in Plan shows the Cross Grain. This is owing to one overlapping the other and being brought into the same Plane as the rest of the Edge.
3.
PLAN.
Developed to show the Side-Cut.
ELEVATION.
4.
PLAN.
Developed to show the Side-Cut.
Enlarged Section through the Soffit. Fig 1.
S
C
O
Enlarged Section through one side, Fig. 2.
Enlarged Section through one side, Fig. 3.
Enlarged Section through one side, Fig. 4
The Angle R Shows the Edge-Cut on the Soffit to fit against the Jamb.
Enlarged Section through the Jamb Fig 1.
B
R
C
C
A
E
Part Plan.
Plan of Edge
The Angle M shows the Edge-Cut.
M
Edge developed to show the necessary Angle, M
The Angle B shows the Edge-Cut on the Jamb, to fit against the Soffit.
Edge developed to show the Angle B.
B
a
e
e
Enlarged Section through the Soffit. Fig. 1
T
Note In Figs 3 and 4 the Bevels for the Edge Cuts are shown at N and O
Part Plan.
Plan of Edge
N
Edge developed to show the necessary Angle, N.
Part Plan.
Mitre Cut.
Edge developed to show the necessary Angle, O.
O

WINDOW LININGS—*continued.*

Fig. 1. Represents half front elevation and part plan of a pair of splayed jamb linings, with a segmental head, the head being part of a right cylinder level at the crown.

When the linings are narrow the head may be cut out of a solid piece, but as a rule they are thin, bent to the necessary curve upon a cylinder, and blocked on the outside to keep them to the proper curve.

In cases of this class it is necessary to determine the true shape of the jamb, to get the depth of trench.

In elevation it is shown at a′ d′, a″ d″, this is the ordinary projection, a″ being the springing, the back-edge d′ is continued until it cuts the soffit in d″, the jambs being splayed at an angle of 45°.

To determine the true shape of the jamb, the full length of the front-edge is shown by the line a′ a″, this line is shown developed a″, a‴. To determine the curve from a‴ to d″, take a few points in plan 1 and 2, erect perpendiculars to cut the soffit in points 1′ 2′, and develop these points as follows, with d as centre and radius d a, turn this parallel to the vertical plane, from the same centre turn points 1 and 2 parallel as well. Erect perpendiculars as shown by the dotted lines, and from points 1′ and 2′ draw the horizontal lines to cut the developed points in 1″ and 2″, draw the curve through these points a‴ 1″, 2″ to d″ and the true shape of the jamb is obtained.

It will be seen that had a line been drawn from a‴ to d″ then it would have left the casing short in the centre.

The thickness of the jamb and soffit is not shown.

When the jamb is trenched into the soffit it is let into it deep enough at the sides to allow a straight cut across the top end of the jamb, and of course this admits of a straight cut through the head or soffit. To curve the jamb head as shown, and make a trench in the soffit for the same would be to add a serious amount of labour to the work, which would be out of sight when the casings were put together.

Fig. 2. Shows a front elevation and plan of a pair of splayed casings with jamb linings, and soffit at the same angle; the head being a semi-circle.

The plan of the casings is shown at a b c d, and a section is shown through A B.

Fig. 3. To determine the true shape of the head, produce the line f z (see section) to o in the springing line C D, then with f o as radius describe the arc C′ D′. Make the length of this arc equal to the semi-circle C A D Fig. 2; having divided the semi-circle Fig. 2, into any number of equal parts, set these parts along the line, from 1 to 14 draw from C′ and D′ to the centre o, then from the section take the line o z, and from the centre o Fig. 3, draw the arc E′ F′. C′ D′ E′ F′ is the true shape of the veneer for the soffit. *Note.* C D and C′ D′ are equal in length.

In linings of this description the head and jambs are joined at the springing line. If the head be a segment of a circle, then the springing line must be determined by projectors from the plan and section; and for length of radius to determine the shape of the soffit, the line f z as in Fig. 2, would have to be produced until it cut the horizontal line through the centre from which the segment had been drawn.

The jambs are usually tongued into the window bottom, and trenched into the head, except in casings like Fig. 2, in which case they are grooved and a loose tongue put in, the whole being glued and screwed together. If the linings are of sufficient thickness then handrail bolts make the best fastenings, but they are generally too thin to admit of any but common screws.

When jambs and soffits are framed, it is a general rule to make the stiles on the jambs, to correspond with the front and back of the soffit.

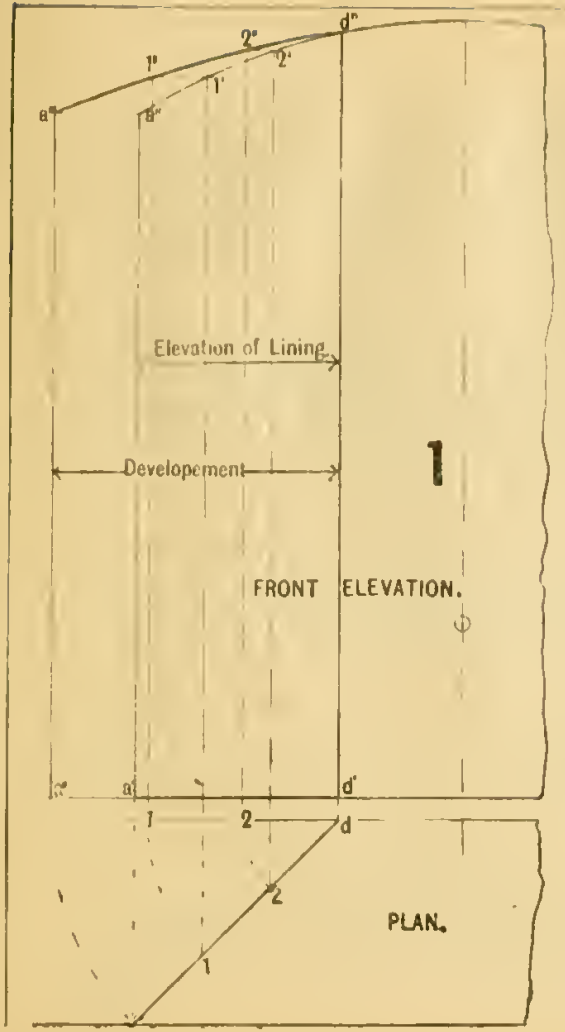
Exercises.

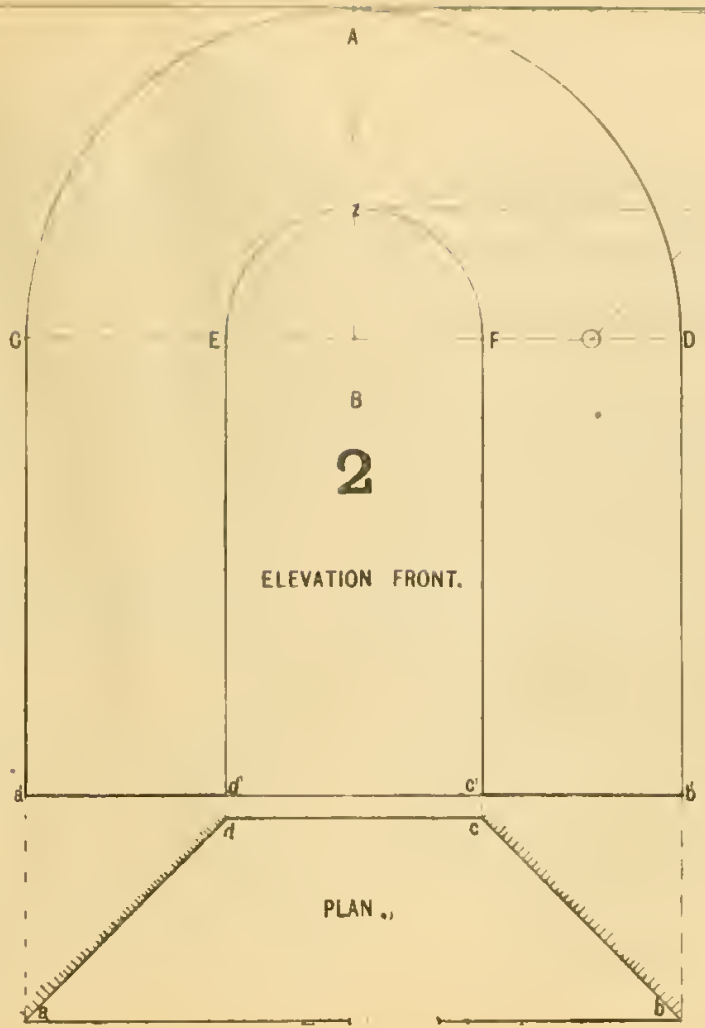
1. The axis of a right cone is 4″, the diameter of the base is 3″, show the development of the surface.
2. Given a sphere 3″ in diameter, supposing it to be divided into eight equal parts by planes passing through its centre.

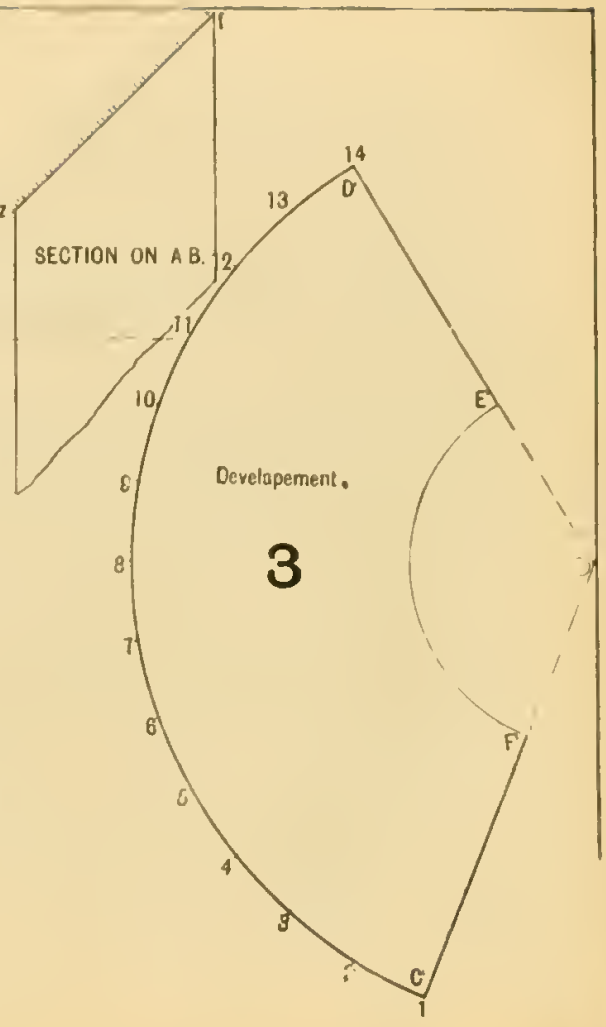
Show the development of one of the curved surfaces.

3. Draw a vertical section through Fig. 1.
4. The jambs and soffit of a window are to be 1½″ thick and framed, the jambs at 45° and the soffit at 60°, the stiles 3″. (Add tongue and necessary bevel.) Show the width of stiles on the soffit to correspond with the stiles on the jambs.

If a small mould has to be planted in the panels of the soffit, explain how an ordinary mitre board may be used to mitre the moulds on.


Elevation of Lining
Developement
1
FRONT ELEVATION.
PLAN.


A
B
2
ELEVATION FRONT.
PLAN.


SECTION ON A B.
Developement.
3

FRAMED AND SPLAYED CASINGS.

Fig. 1. Shows a front elevation, 1a shows a horizontal section or plan, and on the right a vertical section of a splayed and framed window casing is shown.

In the previous plate the linings were taken as plain, but they are sometimes wanted framed, and then the size of timber required for the stiles, has to be determined, (*i.e.*) for the soffit stiles.

In the front elevation Fig. 1, are shown the edge and face of the casings without grooves and tongues, the last so as not to confuse the drawing by unnecessary lines.

The section shows the necessary thickness of plank a b from which to get the front stile, b c being the width of mould or template to mark on the plank for cutting out at the band saw; e, f, g, h, shows the size of timber for the small stile, *i.e.*, the one next the frame. After these have been cut out square, the corners shown by dotted lines have to be taken off, and carefully dressed to the lines marked by the mould, the joints may then be made, and would be held together by joint bolts, and kept from lipping by cross tongues.

The grooves have to be made by a router, or quirk cutter, if not done by machinery. The panels require to be shaped, in order to do this apply the method used for determining the soffit in last chapter. These have been made to appear very narrow in order to show as clearly as possible the quantity of timber required for the stiles.

The above method for determining the size of a circular stile or rail is used, when a horizontal bottom rail for a skylight is required, the plan being a circle, and section a triangle; or for a horizontal bar running round a similar light, or dome.

Enclose the bar, stile or rail, in a square or rectangle as the case requires, as shown in section Fig. 1, and then the quantity of timber required is shown in the section.

Fig. 2. Shows a front elevation of a circle on circle, or double circle.

The present is for a circular headed frame in a circular wall.

Fig. 3. To determine the face mould as shown, divide the outside circle Fig. 2, into any number of equal parts as 1, 2, 3, &c., and erect perpendiculars a1, a2, a3, &c. Draw the line B in plan, and erect perpendiculars through the line B, the same height as a8, a7, a6, Fig. 2. Trace the curve through these last points 1, 2, 3, 4, 5, 6, 7, 8, and make perpendiculars the same length as those on the front elevation, the curve through these points is the bottom edge of the face mould, having drawn this line, the template or face mould is complete.

Fig. 4. To determine the shape of the veneer to mark on the top side of the head, draw a line as b b, these spaces must be equal to the development of the outside Fig. 2, numbered 1 to 8; having marked these spaces at b b b, &c., Fig. 4; erect perpendiculars from b b, &c., b 8, being equal to b 8 Fig. 3, draw in the curve through the points as shown at Fig. 4 and the template or veneer for marking the top side is obtained. The veneer for the underside of the head may be obtained in the same manner.

The sketches have been exaggerated to show as clearly as possible the principle.

The frames are jointed in the centre when small, but large frames often require jointing at two or more places besides the springing.

If a bar be run round parallel to the frame, it is known as a marginal bar, and when radial bars are put in from the frame to the marginal bar, these radial bars are called cod bars.

Exercises.

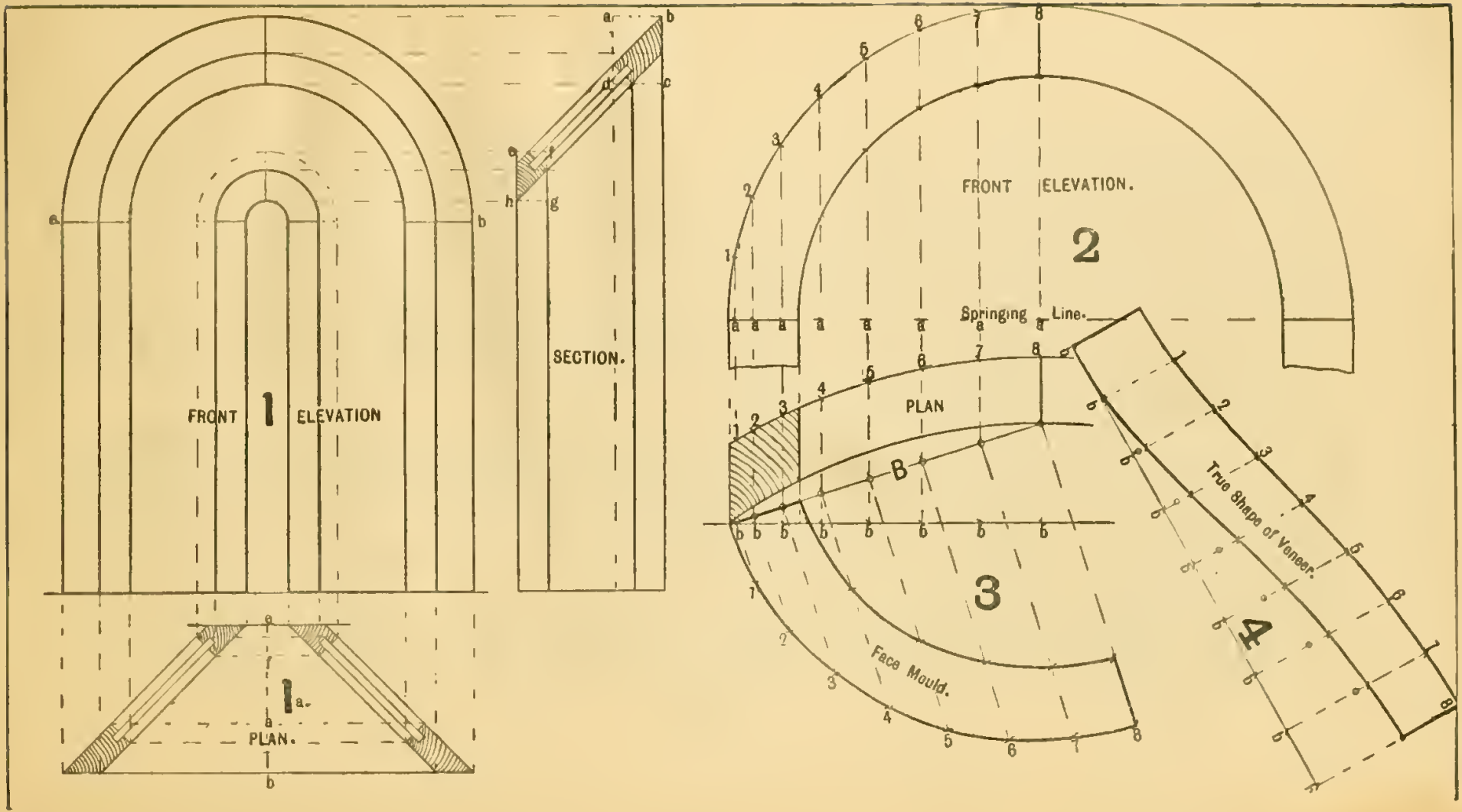
1. The plan of a skylight is a circle; and a vertical section a semi-circle.

Show the size of timber required for a horizontal bar, the ordinary bars being 3″ × 1½″ rebated and moulded.

2. In Fig. 1, put a rail in the centre of the soffit, and determine the shape of the necessary panels.

3. Show a radial, and marginal bar in a similar window to the one shown, and determine the shape of the radial or cod bar.

4. Show the size of timber, and necessary bevels for jointing the frame in the centre Fig. 2. The two sides would be similar to two hips, and jointed in the same way, *i.e.*, before they were cut to the curve.


FRONT 1 ELEVATION
SECTION.
1a.
PLAN.
FRONT ELEVATION.
2
Springing Line.
PLAN
B
3
Face Mould.
4
True Shape of Veneer.

CIRCLE UPON CIRCLE.—*Continued.*

Circular headed Frame, circular in plan, the jambs radiating, and the soffit horizontal at the crown. The head to be in two pieces.

Fig. 1. A B C D is the plan, and E′ F′ the elevation circle. In this case the plan of the elevation circle I I is taken at the outside arris of the jambs in plan. In the case where the frame has to fit a brick or stone arch, this would be the most convenient position, if it can be so arranged, for then the elevation circle of the brick or stone arch would be taken at the inside arris.

To draw the moulds, draw the chord lines A J, D J, and the parallels K L and L M tangent to the outside of the frame, take the points 1′ 2′ 3′ 4′ on the elevation E′ F′, and project these on the line I I at n o p q, and mark off on the left side the same distances, measuring from the centre line at r s t u, draw through these points to the centre the plan is struck from, intersecting the chord lines A J, D J, and the parallels K L, L M, in 1 1, 2 2, 3 3, 4 4. For the outside face mould, draw perpendiculars with K L from the points 1 2 3 4 and L, making L F′=G F′, 4 4′ = 0 4′, 3 3′ = 0 3′, 2 2′ = 0 2′, and 1 1′ = 0 1′; trace the curve from E′ to F′ through the points, and make the mould parallel, draw the dotted line from E on A J perpendicular with K L to v, draw from v to F′, this gives the edge of the plank; draw the line on the face mould parallel with v F′, draw the perpendicular from J meeting v F′ in w, with w as centre and w F′ as radius draw the small arc, draw tangent to the arc and parallel with L F′ to meet K L, draw from the intersection to J, this gives the bevel for the edge of the plank.

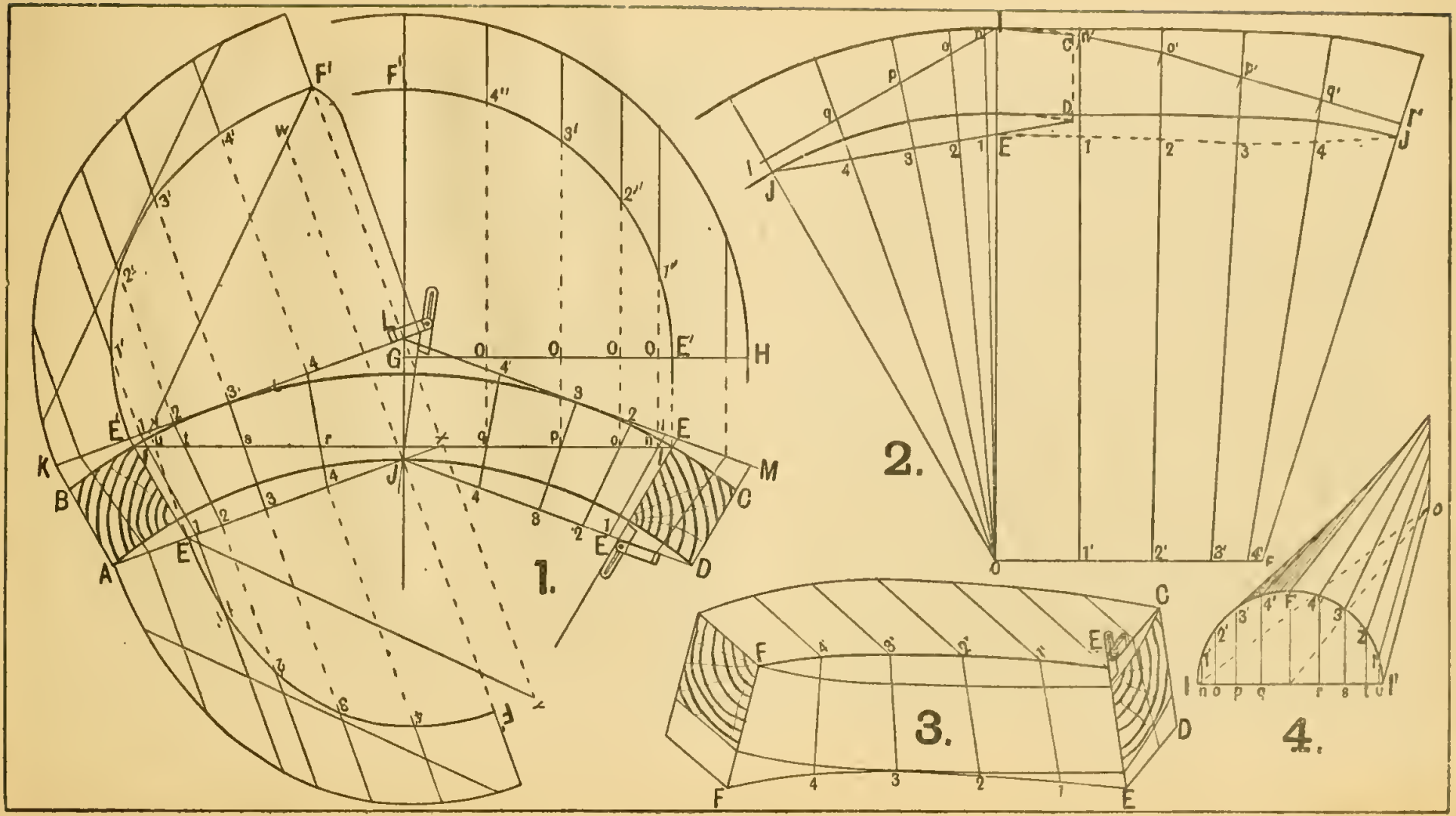
For the inside face mould, draw the perpendiculars with A J from the points 1 2 3 4 and J, making J F′ = G F′, &c., and trace curve through the points, making the mould parallel, draw the perpendicular from L, making x y = L F′, measuring from A J produced draw E y, this gives the edge of the plank, draw the line on the face mould parallel with E y.

Fig. 2. Is one half of the plan re-drawn to obtain the soffit mould. Draw the perpendicular to O E from O, measure off on this the distances O 1′, O 2′, O 3′, O 4′, and G F, taken from the elevation Fig. 1. Then from I with radius E′ I′, taken from elevation Fig. 1, draw the small arc at n′, make I′ n′ = O n, then with n′ as centre and radius 1′ 2′, Fig. 1, draw the small arc at o′, making 2′ o′ = O o, then from o′ with 2′ 3′, Fig. 1, as radius, draw the small arc at p′, make 3′ p′ = O p, then from p′ with radius 3′ 4′, Fig. 1, draw the arc at q′, make 4′ q′ = O q, then from q′ with radius 4′ F′, Fig. 1, draw the arc at I′, make F′ I′ = O I, measure off on 1′ n′ the distances from n to the outside curve, from n to the inside curve, and from n to 1, this is repeated on the other lines, trace the curves through the points, cut the mould out to the outside curve and to the dotted line, this line is held to the inside arris when applied to the stuff and pricked through the line for the inside curve.

Fig. 3. Is a sketch of one side of the head cut out to the face moulds, the lines on the face mould being transferred to the stuff on both sides, the lines on the soffit drawn from each one, the distances are taken from the plan for each line, and the curves traced through them, this must be repeated on the top side, this would do away with the soffit mould, Fig. 2.

Fig. 4. Is a sketch of the conecid, the head in this case being formed by the intersection of a vertical hollow cylinder with this solid.

In applying the face moulds, the joint at the springing is cut square through from the face of the plank, and the bevel a E applied across the joint, and the lines on the face mould must be kept parallel with the edge of the plank, and at the distances shown at Fig. 1.


1.
2.
3.
4.

CIRCLE UPON CIRCLE.—*Continued.*

Fig. 1. Is the plan and elevation of a circular-headed sash, circular in plan, the moulds for the head can be obtained same as those for Fig. 4, page 95. It is usual to show a parallel width on the outside of the sash, there being radial bars, it is necessary to show this width in elevation; the outside of the head is a semi-circle in elevation; take the points 1′ 2′ 3′ 4′ 5′ on it, and project them on to the outside of the sash in plan at 1 2 3 4 5.

Fig. 2. Produce the springing line to the right and set off on it the distances 1 2 3 4 5, and to the outside edge of the stile taken from the plan, project these up to meet the horizontals from the points in elevation, Fig. 1, at 1″ 2″ 3″ 4″ 5″, trace the curve through the intersections, draw the parallel curve at a distance equal to width from rebate to edge of stile where this curve cuts the perpendicular; draw horizontals to meet the projectors in the elevation, Fig. 1, trace the curve through the intersections. The elevation of the line from b′, Fig. 1 is drawn in the same manner.

Draw the elevation from d′ on outside edge of arch bar, make this a semi-circle. Draw the centre lines of radial bars from where these cut the line through b′ at e′ k′ and the centre line from d′ at f′ l′, draw projectors to meet the outside of sash in plan at e f k l, draw from b e d k f l, to the centre the plan is drawn from, cutting the inside of the sash at i g j n h m project i j up to the springing line and g n h m up to meet the horizontals from e′ f′ k′ l′ at g′ h′ n′ m′, trace the curve for the inside of head through i′ g′ n′ o′ and centre line on inside edge of arch bar through j′ h′ m′, both centre lines coming to the same point at the crown.

To draw face moulds for the radial bars draw the tangent line to sash in plan from 1 to y, take points in e′ f′ at 3′ 4′ 5′, project these down to the tangent line, draw lines at right angles to e′ f′ through e′ g′ 3′ 4′ 5′ f′ h′, set off on these lines the distances measured from the tangent line to the corresponding points on the inside and outside of sash in plan, and measured from the line e′ f′ for the face mould. Repeat this at the second bar.

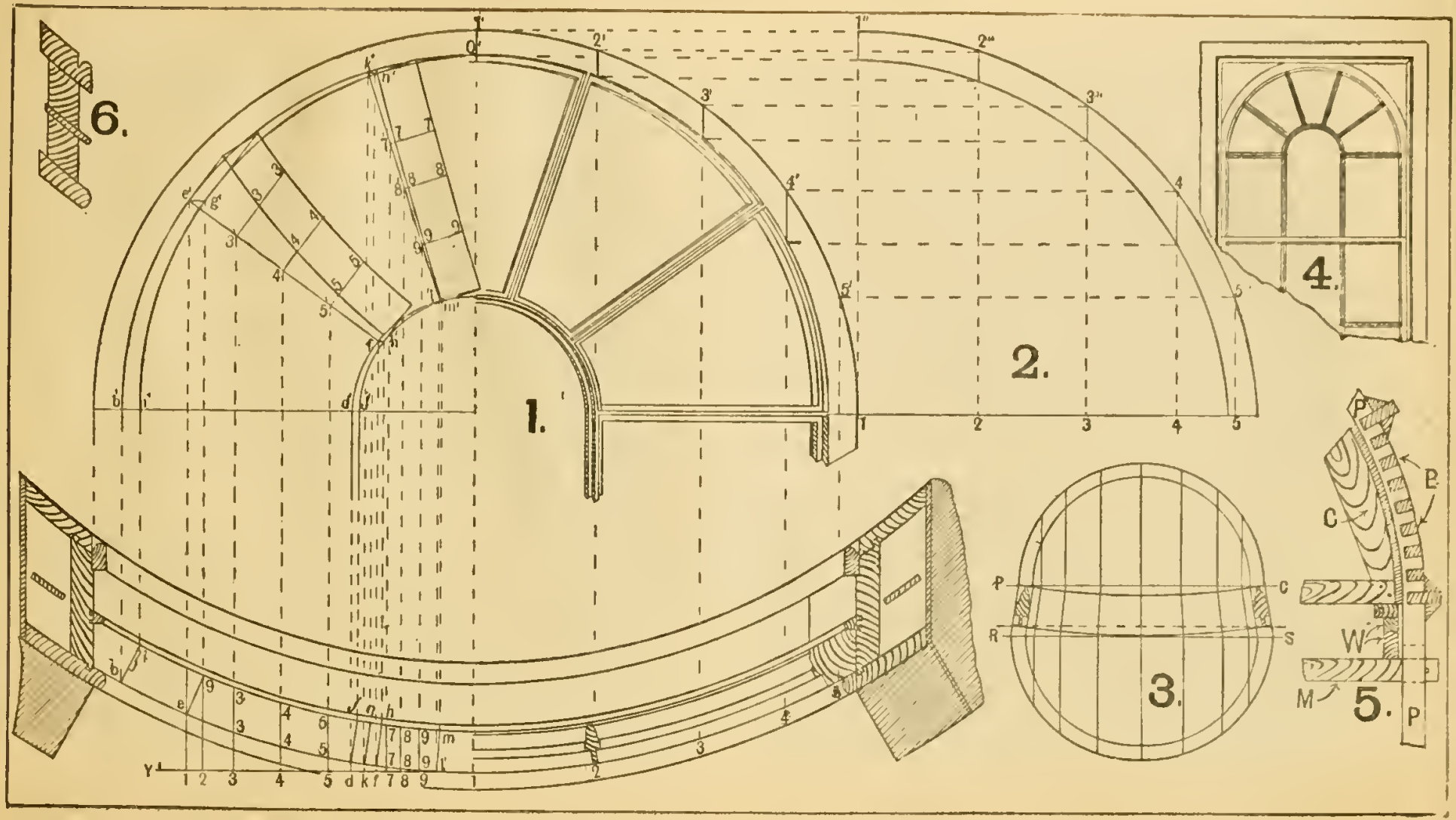
It will be noticed that the elevation of the head is taken as if the moulded portion had been cut away, it being assumed that the rebate and mould are worked to the same depth; that would give the correct shoulder line at that end of the face mould, the elevation of the arch bar is taken through the centre, half the thickness of fillet between rebates must be taken off that shoulder, also on the moulded edge if there is a fillet left on the bar as shown in the present case. Cut the bars out to the face mould square through the stuff, allowing on the ends for the tenons, it will not be necessary to elide the mould on them so they can be cut out the same thickness as the ordinary bars.

Fig. 3. Is the arch bar re-drawn; draw an elevation of the bar on the dotted line making the centre line a semi-circle; take points in this elevation, project them into the dotted line, draw through each point to the centre the plan is drawn from, cutting the chord line p q and the tangent line r s, draw the face moulds as shown taking the heights from the elevation. These are for the arch bar in one piece and jointed at the springing, for this sash it should be jointed at the crown, and the shank ends allowed to run down to the meeting bars, the face moulds then would be a repetition of Fig. 4, page 95.

Fig. 4. Is an elevation showing the usual way these frames are constructed, the head being square, inside the spandril pieces are filled in over the top sash, the head and pulley stiles are rebated to receive them; the outside casings are carried round the usual width and projection.

Fig. 5 Shows part of the head and pulley stile, P, when the head has to be circular, draw the development of the head on a piece of stuff long enough to make the pulley stiles as well as the head, work the pulley stiles up to the springing on the inside and up to the holes for the pulleys on the outside. Trench the head and bend it on a cylinder, C, made same as an ordinary centre, cut a piece of stuff, M, to the plan in between the casings long enough to pass through the holes for the pulleys with a couple of tenons shouldered to the width between the pulley stiles. Insert wedges W between the piece M and the bottom of the cylinder as shown, taking care to get the headwell down on the cylinder and the springing lines equal with those on the cylinder; glue in the pieces B, as shown. When the glue is hard, wedge the pulley stiles, into the sill; remove the cylinder and cut the head out to the development. To work this, notch a straight edge out at one end to the thickness of the casings; this notch is kept on the sill working off the head until the straight-edge touches the piece M, that is shown passing through the pulley holes, keep the straight-edge parallel with the pulley stiles.

Fig. 6. Is a section shewing another method of jointing up the head above the springing.


6.
1.
2.
4.
3.
5.
P
C
R
S
W
M

CIRCLE UPON CIRCLE.—*Continued.*

Fig. 1. A B C D is the plan, and E F G the elevation of a circular-headed frame, circular in plan, the head to be in three pieces. The joints may be arranged at pleasure except that they must be at equal distances from the springing line E G, which is also used as a ground line.

In the present case the inside semi-circle in elevation is divided into three equal parts in the points a′ a′, these are points on the outside of the frame which gives the depth required for the centre piece, draw the chord line a′ a′, parallel with E G, project a′ a′ down to a a on the outside arc in plan; draw from a a to the centre the plan is drawn from, these are the plans of the joints on the under side of the centre piece, draw H I parallel with E G tangent to the outside arc, where the lines from a a cut the inside arc at b b draw the projectors up to b′ b′, draw from the centre O′ through b′ a temporary joint line to C′ (*this line is covered by the line at present shown*), from c′ draw the projector to c in plan, draw the chord line c c parallel with E G, the distance between the lines H I and c c is the thickness required for the centre piece. Where the line c c cuts the lines from a a at d d draw the projectors up to the line a′ a′ at d′ d′, then from o′ draw through d′ the line d′ c′ these are the joint lines on the inside of the centre piece, produce d a to meet H I, from the intersection draw the projectors up to meet a′ a′ produced and through the intersection draw the dotted lines e′ e′ parallel with d′ c′, this gives the full length of the face mould on the outside; draw the joint lines d′ c′ d′ c′ on the face mould, and between these lines is the face mould for the inside.

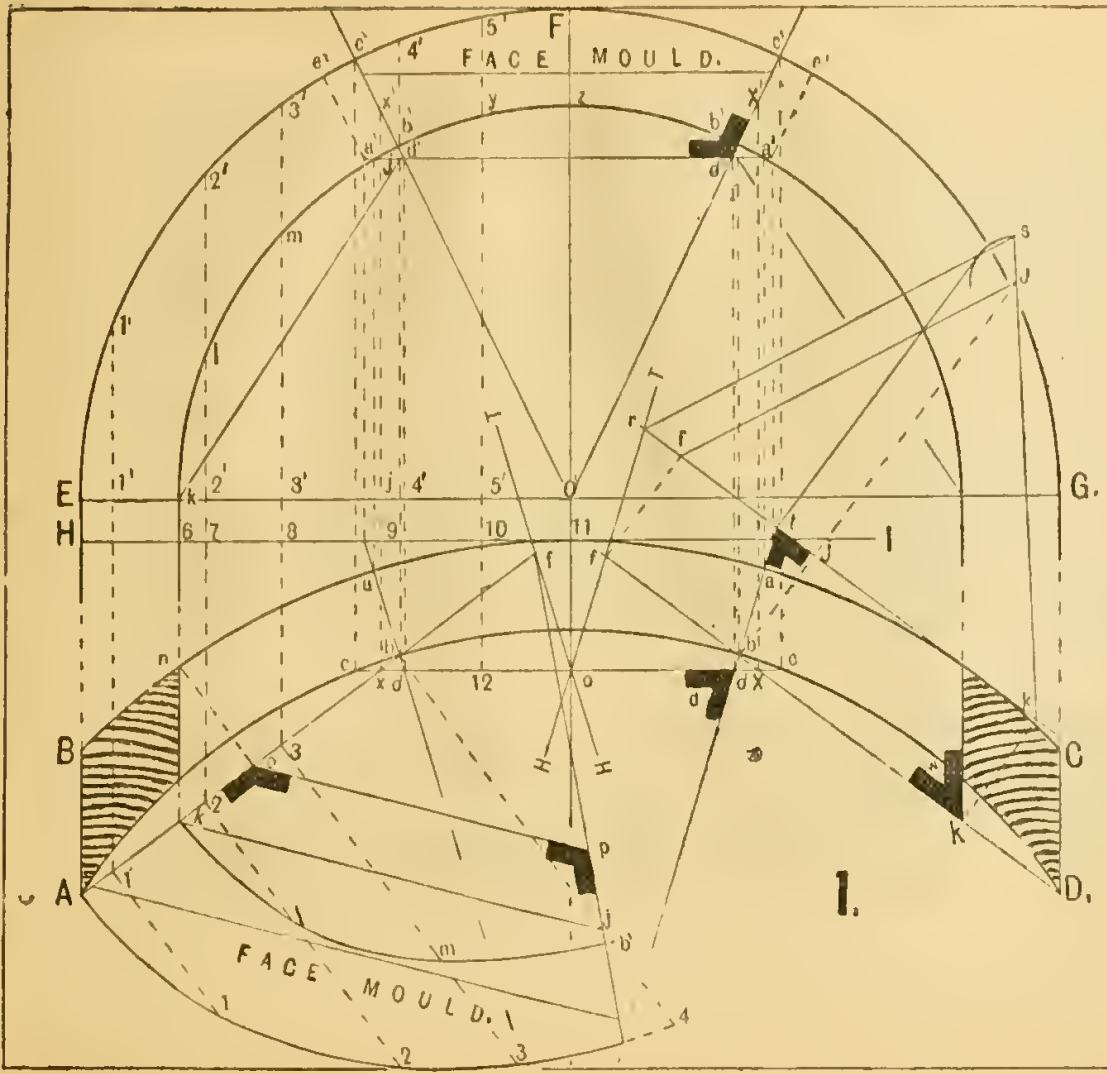
To draw the face mould for the side pieces, first determine the horizontal traces of the planes of the joints. If we take O′ as being in the horizontal plane and the lines O′ d′ c′ being on the inside face of the centre piece, then O in plan will be one point in the horizontal trace of both planes, draw H T H T through O parallel with d a, d a, draw the chord lines from A through b to meet H T at f, also from D through b to f, then take the points in the elevation as 1′ 1′ 2′ 2′, &c. and project them down to meet the chord line A b, from the intersections erect perpendiculars to A b, transferring the heights 1′ 1′, &c., also the points l m b′ and trace the curve of the face mould through them, on the perpendicular from b set off the height J j from b to J which is the height from the springing line to the chord line a′ a′, draw J k from f through j, this gives the joint line on the face mould, also the line A k is the joint line at the springing, the line from n to o at right angles with A b, and the line o P parallel with j k gives the edge of the plank and the distance the face mould must be kept from the edge when applied to the inside. For the bevel across the edge of the plank at the joint, with the centre piece draw C r tangent to the outside arc and parallel with D f, draw the lines f f, b J, k k at right angles with D f and set off on b J produced the height J J measuring from the line C r draw j k and f J, from r draw r s parallel with f J, draw from J with J s as radius the small arc, then tangent to the arc and parallel with J J draw the line meeting C r in t, draw from t to b and in the angle is the bevel; in this case the line from t to b falls on the plan of the joint line. Between D f and C r is the thickness for the side pieces.

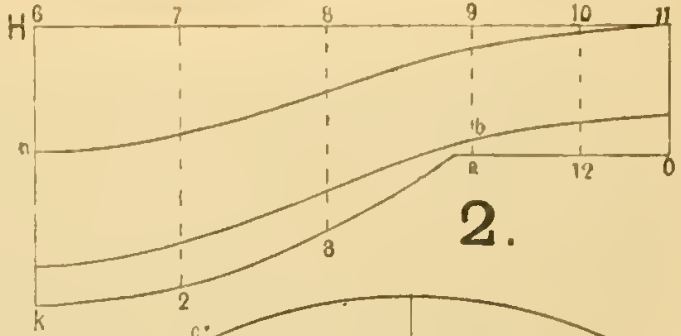
Fig. 2. Is the soffit mould; draw H I, mark off on it 6 7 = k l taken from the elevation Fig. 1, 7 8 = l m, 8 9 = m b, 9 10 = b y, 10 11 = y z and from each point draw lines at right angles with H I, from 6 set off 6 n k taken from the plan Fig. 1 and the intermediate points up to 11 O, cut the mould out to the curved line from n to 11 and to the line from k to o, this edge of the mould is held to the inside edge of the stuff and mark along the outside edge pricking through the line through b, in as many points as is thought necessary.

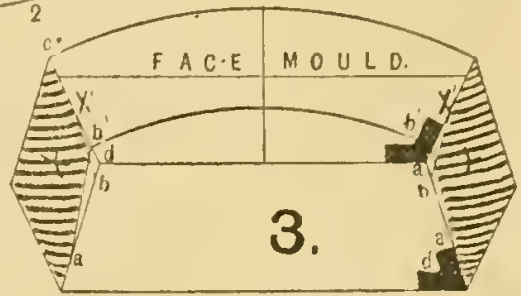
Fig 3. Is a sketch of the centre piece with the face mould applied, the line on the face mould is held parallel with the edge of the plank the same distance from it as it is from the chord line a′ a′, Fig. 1, the bevel at b′, Fig. 1 is applied on the inside face and the bevel at d, Fig. 1, is applied across the edge, the joints must be made before the inside or belly piece is cut out.

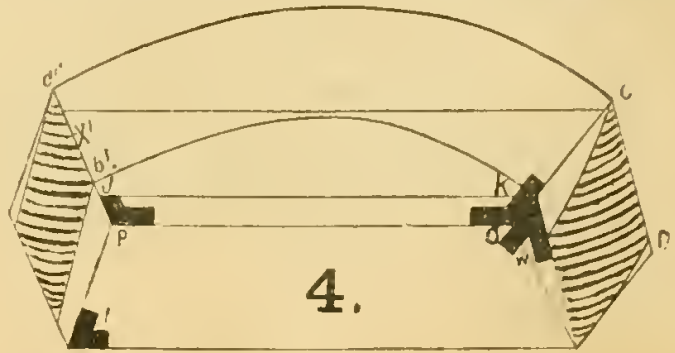
Fig. 4. Is a sketch of the piece for the right side, with the bevels at O P and t applied, the end C D is cut square with the face of the plank not as shown on the sketch which had to be distorted to show the bevels as near their true angles as possible, the bevel at w, Fig. 1, is applied across the end C D, this gives the point the face mould must be held to on the outside, taking care that the line on the face mould is kept parallel with the edge of the plank.

To obtain the position the two must be held together when jointed, refer to the plan, Fig. 1, where the chord lines A b and c c intersect at x this point is projected up to the joint line c′ d′ at x′, this gives one point which is marked on Fig 3, at x′, then again at the plan Fig. 1 take off the distance d b a along the plan of the joint and mark them off on the bottom edge of the joint Fig. 3, draw the line from b to x′ and the line from a to b′ on the joint where they intersect is the point where b′, Fig. 4, is held and the edge b′ c′, Fig. 4 is held to the line b x′ if tried up before the underside is cut out; the point J, Fig. 4, is held to b, Fig. 3. For the position of the joint bolt with x′ as centre, Figs. 3 and 4, and radius about half the width of the frame, draw the small arc, at Fig. 3 where a b′ and b x′ intersect as centre and about half the depth of the frame as radius, draw the intersecting arc, at Fig. 4 with b′ as centre and same radius, draw the intersecting arc, the intersections will be the centre of the joint bolt.


FACE MOULD.
E
H
G.
B
C
A
D.
FACE MOULD.
1.


H
I.
2.


FAC-E MOULD.
3.


4.

BRACKETING.

When very large plaster cornices are introduced, instead of filling up the angle with coarse mortar, and then running the cornice for the finish, rough pieces of timber known as brackets 1½" thick, or so. cut to an outline similar to the required cornice, are fixed 12" inches apart, lathed, then plastered and moulded.

Fig. 1. Shows the plan of a room which requires bracketing for the cornice, A, n n shows an intersection at a right angle, B, m m shows a very sharp angle.

A section of a bracket is given, see A B, the common brackets are shown in plan at o, o, &c.

When a room, passage, &c., only requires to be done on opposite sides, it is a very simple matter, as the brackets are all alike; but when two adjacent or all the sides have to be prepared, then the angle bracket is necessary.

The two shown at A and marked n, n, and the two at B, marked m, m, are internal angles, but one for an external angle might be required, as at a chimney breast, &c.

Fig. 2. In order to economise space, the section of the common bracket has been transferred to A B.

Fig. 3. Draw any line, line p p, making the same angle as the plan of the intersection n n, and mark the points 1, 2, 3, 4, 5, and p p, x y; transfer these points to the intersection p p, and erect perpendiculars, on these set off heights equal to the heights of the first points, at 2, 3, 4, join these and the true shape of the angle bracket is determined.

Fig. 4. Shows the bracket for the acute angle (B, m m) draw any line parallel to the intersection, and a second line at a distance from the first equal to the depth of the bracket; erect perpendiculars and set off the necessary heights, this gives the required points, join them and the desired shape for the angle brackets is obtained.

The points are numbered 1, 2, 3 4, 5, also p, x, and y.

By looking at the plan it will be seen that a sharp angle is formed, the angle bracket being usually made by nailing two thin pieces together. In order to get the necessary or true bevel on these, so that the laths when laid across the ordinary brackets and into the angle may have a level surface to nail the laths against, the same method may be used as for backing a hip, but when several inclinations have to be made in the same piece, and a pattern got out for it, all that is necessary is to move the pattern until it reaches the extreme point, and mark a second line, which shows the amount necessary to be taken off.

In this example the pattern requires sliding from x to x′, see projectors from the plan, then the shade-lined piece shows the amount to be taken off.

It must be borne in mind that the thickness of the piece to be bevelled by this process must be carefully drawn in plan, and at the proper angle, any deviation from one, or both, of these conditions will make it impossible to work the bevelling by the method just described.

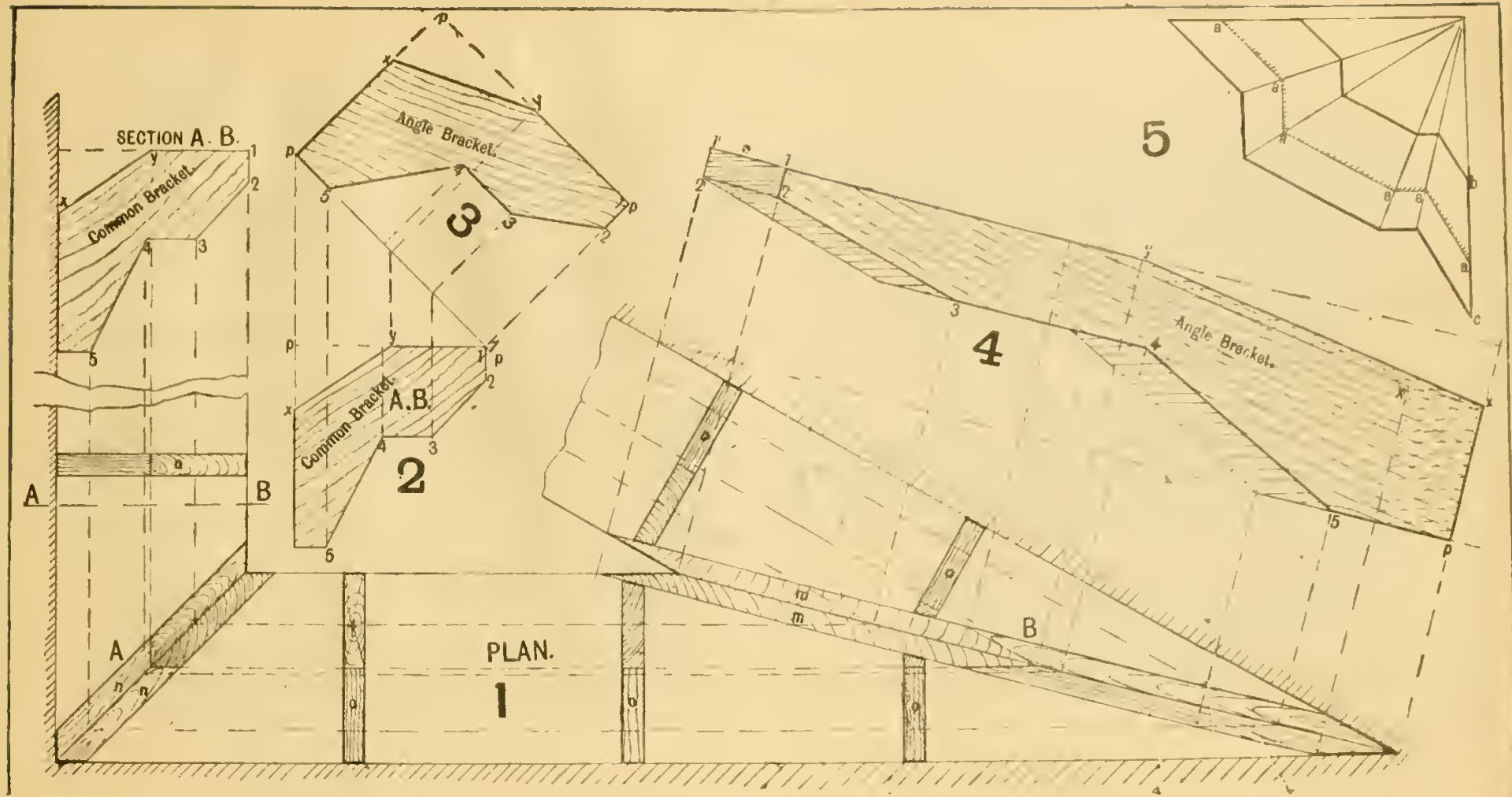
A dotted line from x′ is shown parallel to the top edge x y, this shows the amount necessary to be taken off the top side of the brackets, if it had been required to back that side. From x to x′ shows the piece to be taken off the end in order that it may fit the angle.

Fig. 5. Shows how to reduce or enlarge a bracket similar to a given one, let a a a, &c., be the given one, and let it be required to enlarge it to c, draw the lines from the corner through a a, &c., and through the angular points and produce them, draw from c a line parallel to a a, and all the others similarly, and the enlarged bracket is determined.

If to reduce to b, then draw parallel lines to the first; and a correspondingly reduced bracket will be obtained.

Exercises.

1. If a similar bracket be required for the corner of an octagon plan, determine the angle bracket.
2. Show the necessary amount of bevel for the angle bracket n n Fig. I.
3. Determine the size of the small brackets o, o; next to the acute angle B.
4. Show by your drawing that in two angles, one a right-angle and the other for the angle of an octagon, (the brackets being the same thickness) that in order to obtain the backing the templat must be moved as far again or double the distance, for the first, as for the second. Scale, &c., at pleasure.


SECTION A. B.
Common Bracket.
Angle Bracket.
Common Bracket.
A.B.
Angle Bracket.
PLAN.
1
2
3
4
5
A
B

BRACKETING, ENLARGING and DIMINISHING MOULDS.

Fig. 1. Shows a right section of a bracket, the profile being a segment of a circle. The space from o to 5 represents the perpendicular distance against the wall, and the distance o to 1 shows the distance along the ceiling. Take any number of points in the curve as 1, 2, 3, &c.

Fig. 1a. Draw a line to represent the angle or intersecting line as o to 1, and from the first points draw in the lines 2, 2, &c , then from the points on the angle line, erect perpendiculars and make the line 2, 2 for the angle the same length as at Fig. 1. Draw in the curved line through the points, this gives the necessary outline for the angle bracket.

Fig. 2. Represents a side view or section of a cornice. In these it is often necessary to enlarge or diminish the cornice, keeping all the members in the same proportion.

Fig. 3. Let it be required to enlarge as shown; draw the perpendicular line 1 to 8 Fig. 2, and set out from point 1 a line of the same length that the cornice has to be in depth, this line must be drawn from the top corner marked 1 until it cuts a horizontal line through point 8 to h, then the horizontal lines through each of the other points meeting the extended line, determine the necessary increase for each member. To get the desired increase of projection, draw a line from 8 to cut the wall or face line in the point a, the distance a to 8 being the required projection that the enlarged cornice must have.

Drop perpendiculars from the various members upon the line as a b c d, these spaces show the required enlargement of each member.

Having obtained these and the required perpendiculars, set them off at any convenient place as at Fig. 3, draw projectors through a, b, c, &c.

Set off the necessary depths found on the inclined line 1 to 8, Fig. 2, draw through these points until they cut the corresponding lines from 8 to a, &c., then a line drawn through these intersections gives the required outline for the enlarged mould.

To reduce a cornice, &c.

First take the perpendicular from 1 to 8, Fig. 2, and on this line draw an equilateral triangle, the apex being at o, at the necessary distance from the apex, draw a line of the required length as seen at n n, Fig. 2. From the perpendicular line first drawn, on which the real depth of each member of the cornice has been projected, from the various points as 1, 2, 3, &c., draw to the apex o, and where these lines cut the new base n n, show on that line the necessary reduced sizes of each of the members.

Fig. 4. Represents the cornice so reduced, the projection over the wall or framing shown by the line z, is obtained in a similar manner to the reduced depth on the line n n.

From the foregoing it will be seen that angle brackets are merely enlarged ordinary brackets, the enlargement being in one direction only; a moment's reflection will convince anyone that the perpendiculars are all the same for a common or an angle bracket, the extended lengths being the horizontal portions parallel to the ceiling line.

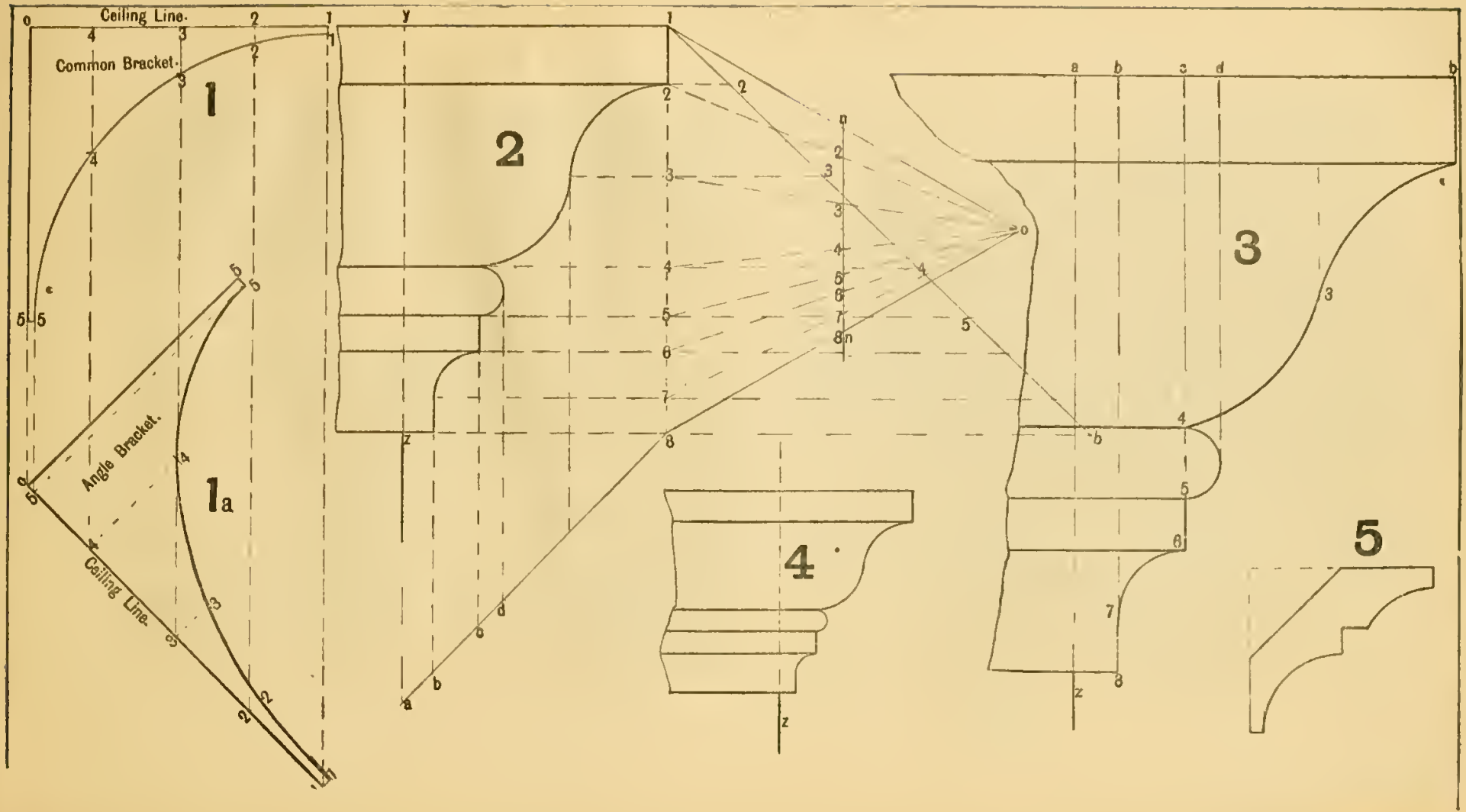
Exercises.

1. Draw Fig. 5 to three times the size, and considering the bracket so drawn as the external bracket for the corner of a hexagon, determine the common brackets.

2. Let Fig. 5 represent the angle bracket for an internal angle of 30°, draw a corresponding common bracket.

3. Show the necessary lines for reducing the projections of Fig. 2, so that the reduced size may be Fig. 4.

4. Show how far the mould for backing the angle rib, Fig. 1, would require sliding along. Show the piece to be taken off by section lines, the angle to be a right-angle, and the thickness of each piece 1¼".


Ceiling Line.
Common Bracket.
1
Angle Bracket.
1a
Ceiling Line.
2
3
4
5

ANGLE AND RAKING MOULDS.

When moulds meet at other than a right angle it is necessary to determine the corresponding angle mould.

Fig. 1. Represents the plan of an angle requiring a bar to intersect with a moulded head; the mould being the same as that shown on the stile A.

The present case is a very common arrangement for shop fronts, but the angle that they make may be varied to suit circumstances.

The pattern of the mould is arbitrary; and unlike ordinary windows the glass is put in from the inside, and secured with putty or beads.

Having the common section at A, Fig. 1, to determine the angle bar B, divide the common mould A into a number of parts as shown by the points 1, 2, 3, 4, 5. The moulded part for the angle bar must be the same from 1 to 5 as the common one at A, make the front edge square and set off spaces equal to those on the common bar, project lines from the points 1, &c. to cut the mould in the various points shown by the dotted lines, draw lines parallel to the front side until they cut lines from points 1, 2, 3, 4, 5, on the angle bar parallel to the mitre line, and the intersection of these lines determine points in the mould for the angle bar.

Fig. 2. The sills and heads are usually mitred at the angle, and a hardwood double dove-tailed piece let in across the joint as shown at a b c d.

To fix the angle bar to the sill and head it has a small stump tenon and a screw, if not too expensive then a bolt and nut is used, the nut being let in from the glass rebate so as not to mar the apppearance of the mould.

Fig. 3. Shows a section through the sill.

Fig. 4. Raking moulds. Let the return mould at the bottom be the one given and let it be required to determine the section of the common one as shown by the thick outlines; erect perpendiculars as at the point marked 5, and draw the horizontal line on which are marked spaces, figured 1, 2, 3, 4, 5, from those points drop perpendiculars to cut the outline of the mould, next draw a line square to the pitch of the pediment, in the present instance it begins from the point marked 5. With point 5 as centre and radius 5, 1, &c., describe arcs as seen, and from the points thus determined, drop perpendiculars from points 1, 2, 3, 4, 5 cutting lines from the corresponding numbers, as 2, 2, 3, 3, 4, 4, and the true section of the mould is obtained. These last lines are taken parallel to the pitch of the pediment.

If the true section had been given, then to determine the other it would have simply been reversing the process.

Fig. 5. Shows a pediment head over a door or window, where a similar mould to Fig. 4 is used.

Fig. 6. Shows a segmental head for a pediment, a true section of the mould is shown by dotted lines. In determining a true section of this class, it is necessary to take a plane passing through the centre of the circle from which the segment was drawn.

To determine the return for the end, apply the same method that was described for a pediment head when pitched like a roof.

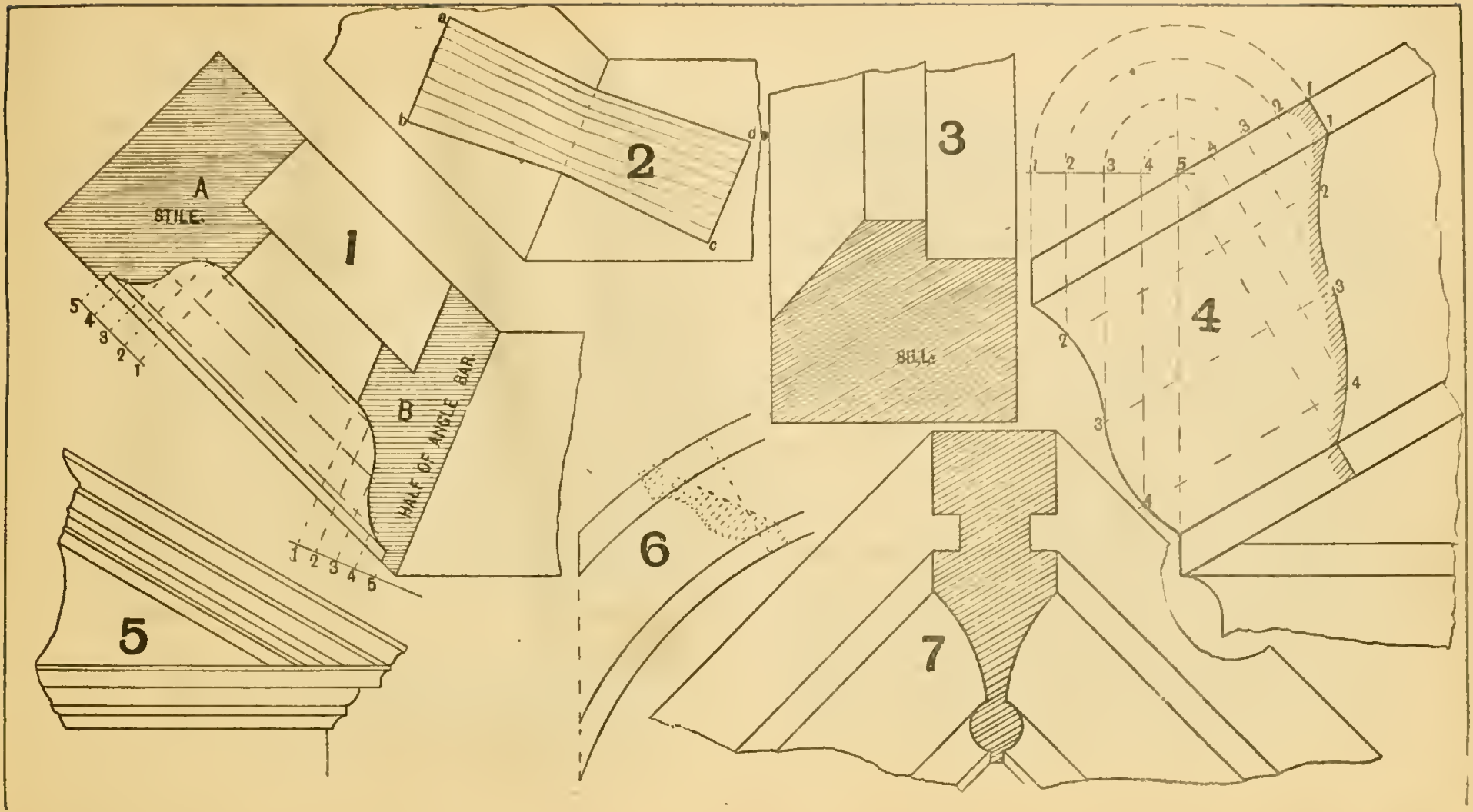
Exercises.

1. In Fig. 1 finish the angle bar (*i.e.*,) draw the other half.

2. Let the angle bar be chamfered instead of moulded, and determine the bevel on the bottom to fit the sill. The section of the sill being the same as Fig. 3.

3. Determine the return end for the mould, see Fig. 6.

4. Let Fig. 7 represent a section through a moulded ridge for a small skylight (half-size) and the pitch of the roof 45° as shown. Determine the true shape of the moulded bars, so that they may intersect with the ridge into which they have to be mitred.


A
STILE.
1
B
HALF OF ANGLE BAR.
5 4 3 2 1
1 2 3 4 5
2
a
b
c
d
3
SILL.
4
1 2 3 4 5
5
6
7

RAKING MOULDS—*continued.*

For Billiard rooms, &c., lighted from the roof, it is not unusual to have the bars, ridge, hips, &c., moulded so that they may all mitre together at the junctions. In addition to the above a bedmould is shown planted on the curb, the former intersecting with the common bars, and also with the hips in the angles.

Such an arrangement is expensive, the moulds being of different shape; if only one light has to be made, the moulds are worked by hand, as it would be too expensive to have irons made for the machine. In this the great difficulty is to get the true shape of each piece.

Fig. 1. Represents a vertical section or elevation.

Fig. 2. Shows the plan.

Fig. 3. Shows the construction for determining the backing for the hips. The last two are line diagrams.

Fig. 4. Shows the true shape of the ridge.

Fig. 5. Shows the true shape of a bar.

Fig. 6. Shows the true shape of the bedmould.

Fig. 7. Shows part of the curb.

Fig. 8. Is Fig. 6 transferred for convenience.

Fig. 9. Shows the true shape of the hip.

Let the plan, elevation, shape of bar, size of ridge, and pitch of roof be given, to determine the necessary raking moulds as shown.

Draw in the bar (Fig. 5) full size, and divide the moulded portion into any number of parts, say 1 to 5, drop perpendiculars from the pitch through these points, and where they cut through the mould draw in the lines marked a, b, c, d, &c., parallel to the pitch of the roof, and produce these both ways until they cut the ridge at the top and the bedmould at the bottom. On the ridge set off the space o to 5 equal to half the thickness of the bar, and the spaces 1, 2, &c., equal to those on the bar, draw perpendiculars from points 1, 2, 3, &c., on the ridge, until they cut the corresponding points on the lines a, b, c, &c., where these lines intersect are the necessary points in the mould for the ridge. Draw in the curved line through the points, and the true shape for the ridge is determined.

For the true shape of the bedmould, (Fig. 6) treat it the same way as the ridge.

At any convenient place draw two lines M, N, making the same angle as the lines b z c, Fig. 3, make the thickness of the hips equal to the thickness of the ridge.

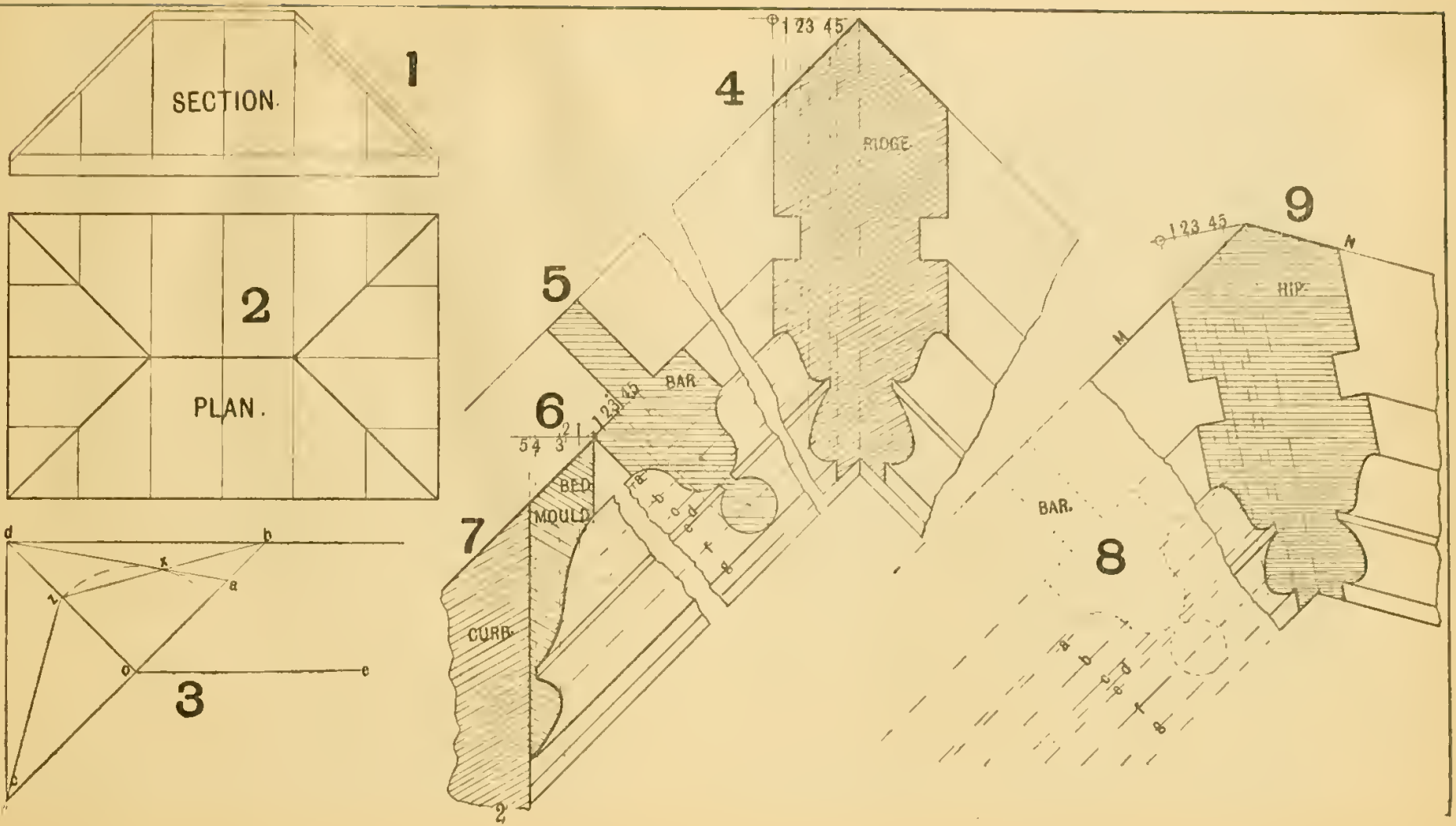
Fig. 8 shows an outline of the bar (Fig. 5), it is not necessary to re-draw this, as the spaces between the lines a, b, c, &c., may be copied from Fig. 5. On the top of the hips set off the necessary spaces 1, 2, 3, 4, 5, and from these points draw lines perpendicular to cut lines parallel to M, and where these lines meet determine, points in the mould for the hip. Sometimes a small fillet is left on the bar so that it is level with the underside of the ridge and hips; this and the pattern of the bar are purely matters of opinion. When the skylight is very large it may be necessary to increase the depth of the hips and ridge, this may be done by moulding a piece on the hips and ridge to correspond with the moulded bar, and make the hips and ridge deeper and thicker, the extra depth and thickness being moulded so as to mitre.

Fig. 9 is the true shape of the hip, and its form is determined in the same manner as the ridge. In order to draw the two lines M and N see Fig. 3. Let c b d represent the plan of the curb, o d the plan of a hip, o e the plan of the ridge. Draw any line square to the plan of the hip, the line c b is square to the hip o d, then on the line c b from o, set up the height o a, this is the rise of the roof, join a to d, this is the true length and inclination of the hip, draw o x at right angles to a d, and make o z equal in length to o x, then o x is the depth, square off the hip at point o, and cutting out a c, join z to b and c, and the backing of the hip is obtained. (This has been more fully explained in a previous chapter.)

These lights usually surmount a roof slated below, in which case the curb is deep enough to receive the spars, &c., in addition to a small drip off the glass. If vertical sides be used and glazed, then it is called a lantern light.

Exercises.

1. Determine the true length of the bars.
2. Draw a plan of the underside of a hip at one corner, and the bedmould (Fig. 6) intersecting it; also one bar.
3. Let Fig. 6 represent a ridge, and deduce a common bar from it.
4. Let the bar be 3″ × 1¼″, the ridge 9″ × 3″, and hips to correspond. Draw the mould for the ridge and hips. Scale, &c., at pleasure.


1
SECTION.
2
PLAN.
3
d
b
x
a
z
o
e
c
4
1 2 3 4 5
RIDGE.
5
BAR.
6
1 2 3 4 5
5 4 3 2 1
BED
MOULD.
7
CURB.
2
a
b
c
d
e
f
g
8
BAR.
9
1 2 3 4 5
HIP.
M
N

INTERSECTION OF STRAIGHT AND CURVED MOULDS.

Fig. 1. Represents the head of a frame square with the stile, and having a quadrant in the angle. The quadrant c represents a bar moulded to the same pattern as the head and stile, and intersecting with them. In cases of this class the line of intersection is curved, Draw the lines on the head and stile, also those on the bar c to represent the members of the mould, and where these meet show the necessary points in the line of intersection, having obtained these points, sketch in the curve through them, and the line of intersection is complete.

When the top side of a lockrail is a segment, or a semi-circle, then the above rule applies for determining the intersection of the moulds; an arrangement of this class gives a great amount of labour. In cases like the above, if the intersecting line be straight the moulds will not be exactly alike, though they may be so near as to deceive the eye.

Fig. 2. Is an elevation of a vestibule glass door and side lights; the door being worked on centres and known as a swing door. The head and posts may be moulded as desired, the posts run up to the head, the transome being cut in between them.

When glass is used for the top panel, it is usual to reduce the stiles above the lockrail, and mould this part like a sash. The stile may be reduced according to taste, but sufficient must be left to give the necessary strength to the door.

Fig. 3. Having given the lockrail and stile both above and below, either plain or moulded as shown, proceed as follows to determine the bevel for the shoulders on the lockrail, draw both top and bottom side to meet the stile, also a line on the stile and lockrail to represent the depth of mould meeting at a, join a to b, and the necessary bevel or shoulder line is determined. When the sinking for glass and depth of mould are the same, it must be remembered that the shoulder on the glass side is only the same bevel as the front side; the sinking may be more, or less, any difference must be allowed for, when marking the shoulder line.

In the bottom of the door the ordinary muntin is omitted, and the glass panel in the top often has a marginal bar. The fanlight is filled in with glass to match the top part of the door, and side lights. The latter are occasionally made in three heights, a strong piece being put across level with the top of the lockrail.

The panels may be moulded to any desired pattern.

Fig. 4. Is an enlarged detail showing how the joint between the transome and post is made and secured. The figure represents a vertical section through the joint, the tenon being the usual thickness and dovetailed as shown. Whilst the sloping part is kept close, by the wedges x, x, the heading joints are slightly open, this allows the shoulders to bear solid on the post. It must be observed that the amount of slope on either b or c cannot exceed the piece taken out of the post a, for wedges, or the tenons cannot be got in. A handrail bolt makes a good joint, but the above is simple, cheap, and effective.

Fig. 5. Is a horizontal section through one side of a swing door, (as shown at Fig. 2.)

To determine the position of the centre o, so that the door may open square as shown by the dotted lines; from the face of the post at a b′ set off half the thickness of the door, and in the centre at c, is the necessary point; then with c as centre, and c a or c b as radius, draw the curve, this is the necessary round for the door edge. In order to have a little clearance in the door post, take a less radius as o a, then with o as centre, o a or o b as radius, draw in the second arc, this allows ample space.

Fig. 6. Shows what is known as a rule joint, a being fixed, and b a loose piece, c shows the two at right-angles to each other. The centre of the hinge is let in a little below the level, so that the joint will not be open when the two are at right-angles to each other. This joint is used when it is desired to give a neater finish than the square edges, for such as tables, window shutters, &c.

Fig. 7. Is the plan of a small door with a capping, &c., on the top. This class of door is used in low framing for banks, counting-houses, &c., the object being to give the top the appearance of an unbroken surface when the door is shut. If the hinge could project far enough inside, then a square joint might be used, the front edge of the door only being bevelled. The knuckle of the hinge in this case has its centre in the edge of the door. From the centre o with a b as radius draw the arc b a, the distance from a to y must not be less than y o or x o, otherwise the door will not open square, the space a f merely gives clearance. The dotted lines a′ b′ c′ m n show the door when open. The shaded portion shows the fixed piece of capping on the frame.

Fig. 8. Shows a section through the top of the small door (Fig. 7.) capping, etc.

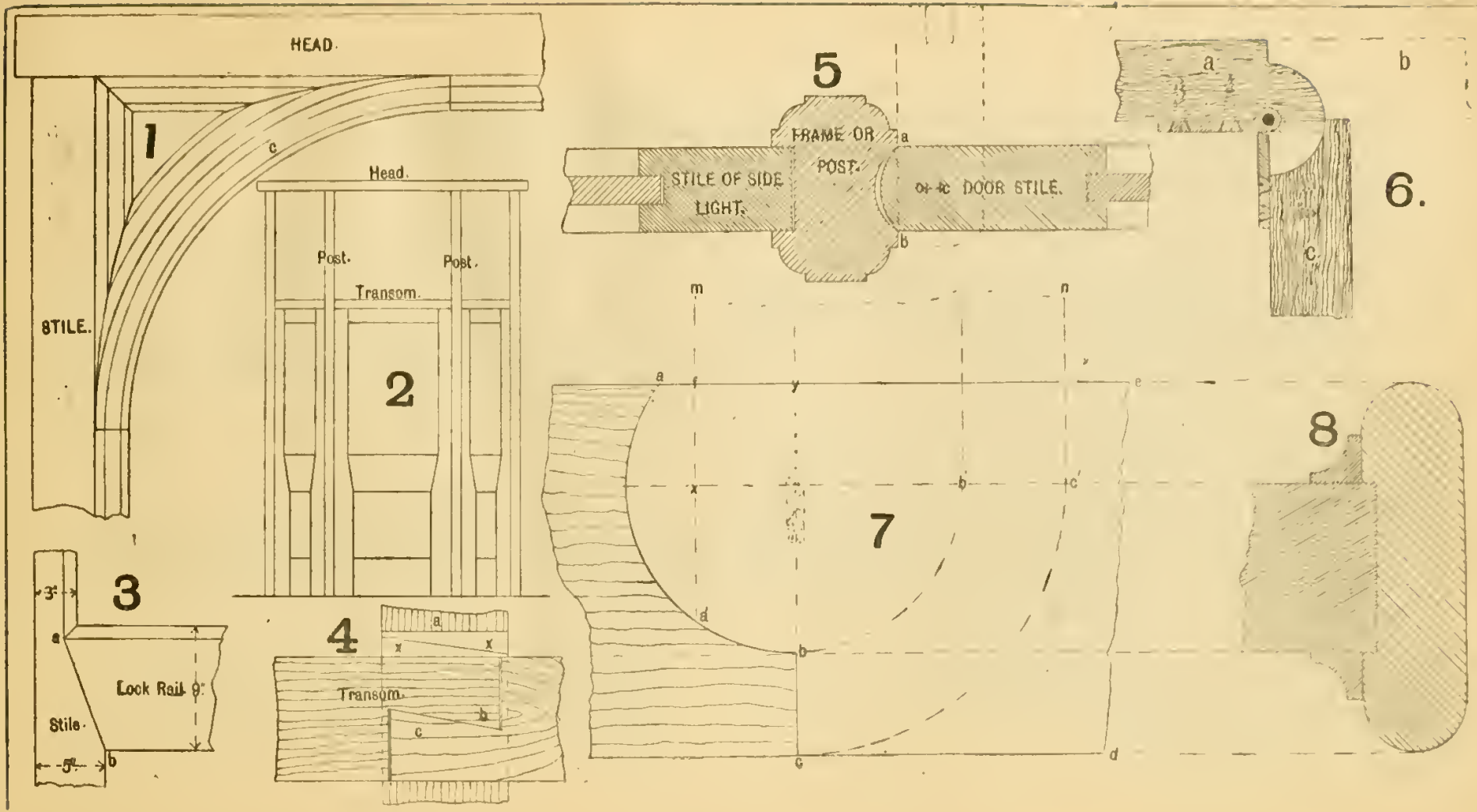
Exercises.

1. Show both front and back joint or bevel for the lockrail, when the mould is $\frac{3}{4}$″ and the glass $\frac{1}{2}$″. (See Fig. 3.)

2. Show the necessary round on the front edge of the door. (See Fig. 5.)

3. Show where the scotia should be cut in Fig. 7, also the necessary bevel on the front edge.

4. In Fig. 1. Let the mould on the stile and head be given, and the intersecting line a straight one. Show the section of the bar. Scale, &c., at pleasure.


HEAD.
1
c
STILE.
Head.
Post.
Post.
Transom.
2
3
3"
a
Lock Rail 9"
Stile.
5"
b
4
a
x
x
Transom.
b
c
5
FRAME OR POST.
a
STILE OF SIDE LIGHT.
DOOR STILE.
b
a
b
6.
c
m
n
a
f
y
e
x
b
c
7
d
b
c
d
8

HINGEING COMMON DOORS.

When doors are rebated into frames in the ordinary way, and hinged to one edge, the opposite edge requires to be bevelled; if a door be thin say 1″, and 3′ wide the bevel is always imperceptible.

It is only when the door is thick and narrow, and the bevel begins to show itself, or when the doors are folded and rebated. In such as Figs. 2, 4 and 5 it is absolutely necessary to determine the bevel.

Fig. 1. Represents a common door and frame, a being the frame, the usual depth of rebate being ½″, and the centre of the knuckle in the joint as shown at c. To determine the necessary bevel for the edge, draw from c the diagonal c d, and on c d place a square, or draw d e at right-angles to c d, and the necessary amount of bevel is determined. In the present case the frame is shown with a corresponding bevel; when this is not done, a hollow corner is left at d, this is not observed when the door is shut, as the joint at e may be as close in one case as the other.

Fig. 2. Is a horizontal section through a pair of folding doors, rebated at the joint in the centre. In order that the first door may open freely, it is necessary to bevel the edge; the door to the right shown by lighter shading is the one to open first. Let c be the centre of motion (*i.e.*, the centre of the knuckle of the hinge) draw a line from c to a then draw a b at right-angles to it, and the bevel for half the thickness is determined. For the other half, draw the line c b, and draw b d, square to c b, this is much less than the first half; sometimes the bevel is made the same as for the first.

If c and c had been removed from the face of the frame the bevel for the edge must be increased in order to allow the door to open clear off a block or plinth. In no case can both doors be opened at the same time, because the distances from c to a plus c to a is greater than the distance from c to c.

Fig. 3. Is the plan of a door hinged at c, the section being a segment of a circle; if a line be drawn from c to a, and a line c d at right-angles to a c, the necessary clearance is obtained.

In some cases a neater finish is obtained by making the joint radiate to the centre, as shown by dotted lines.

Fig. 4. Is given to show what the joints would be like, when a circular door is made to fold, and the centres of the hinges are at c, c, the door on the right opens first. Draw from c to a, and then a line a c drawn at right-angles to a c, gives the necessary bevel; for the other, proceed in the same way, join c to b and draw b d square to c b, and the requisite bevel is determined.

Fig. 5. Shows the bevels required for a similar door when hinged to open towards the centre of the circle, the same letters are used as for Fig. 4, and need not be repeated. The above are not drawn to scale, and are out of proportion, in order to show the method of bevelling.

Fig. 6. Illustrates the methods of hingeing a flap to open over a space from x to y, this is done by projecting the centre of the hinge to o, which is equal to half the space to be opened over. The piece a is fixed, and b is a loose piece or shutter, shown open by dotted lines; when the knuckle of the hinge is projected in this manner it is called a parliamentary hinge.

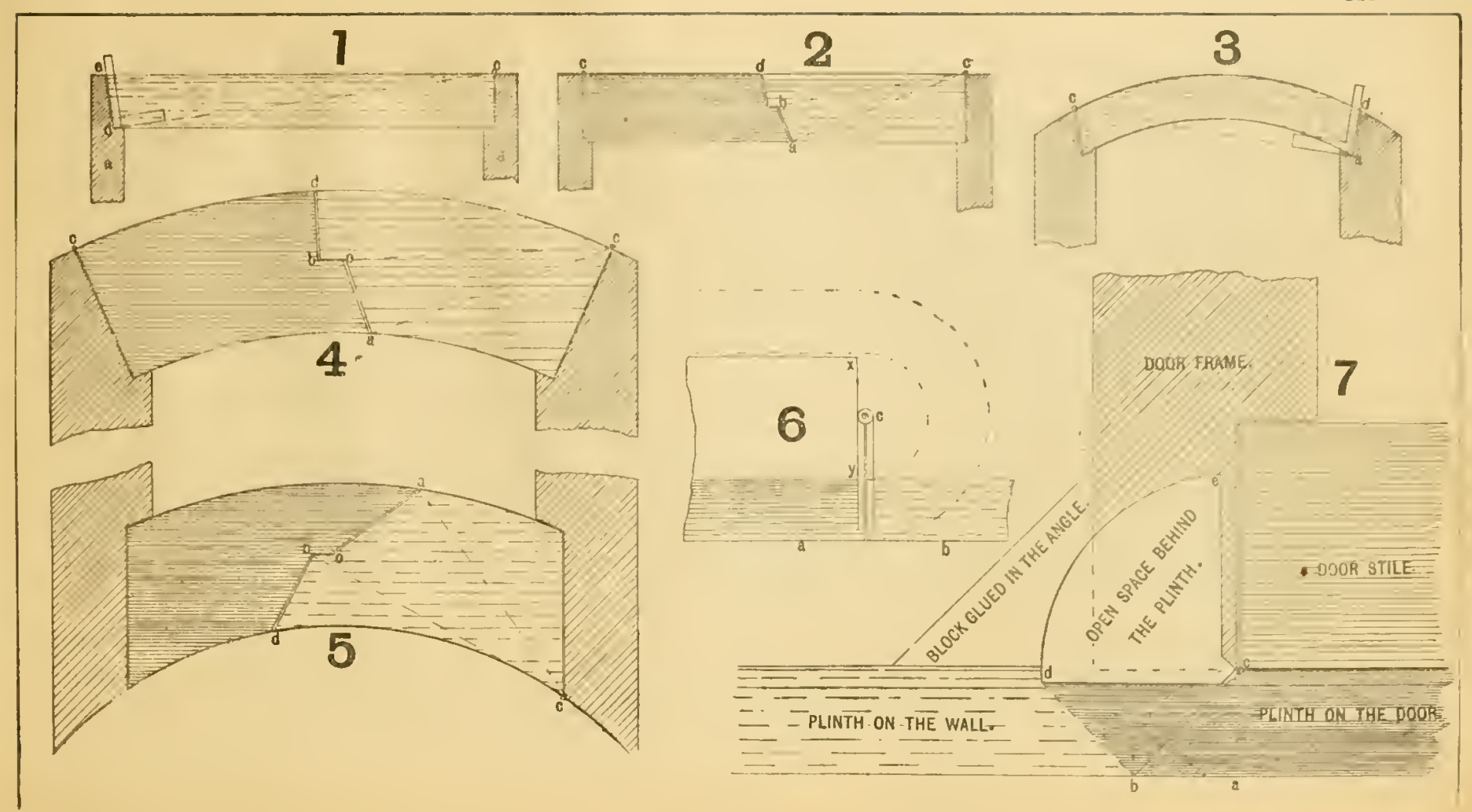
The same may be obtained by hingeing a stile equal to the depth it has to turn back from x to y, and then hingeing the shutter to this, which gives an extra joint.

Fig. 7. Shows a jib door, the plinth being continued across the door.

Let c be the centre of motion, draw the line c a, and set off a b equal to c a, so that the door may open square, draw b d square to c b, then with c as centre and radius c d, draw the quadrant of the circle shown at d e, this space is left open, to allow room for the plinth to turn in when the door is being opened. The piece of plinth fixed on the door is shown darker than the piece on the wall.

Exercises.

1. In Fig. 2, project the knuckle of the hinge half the thickness of the door, and show the joint at the centre.
2. Show how you would form the joint, keeping the hinge out of sight.
3. Use a loose stile to obtain the same result as in Fig. 6.
4. Show the bevel for the front edge of the door in Fig. 7, and explain why the plinth need not be bevelled at the same angle as the door edge.


1
2
3
4
5
6
7
DOOR FRAME.
DOOR STILE.
BLOCK GLUED IN THE ANGLE.
OPEN SPACE BEHIND THE PLINTH.
PLINTH ON THE WALL.
PLINTH ON THE DOOR.

BEVELS FOR HIPS AND JACK RAFTERS.

Fig. 1. Represents part elevation and plan of a small roof, one end being hipped.

To determine the length and inclination of the hip, a c or b c. In the present case the pitch is taken at 45° for both sides and end, the plans of the angles at a and b being right-angles, (the hips are as a matter of fact the same length ;) take the length in plan a c, and set this length off from d to f in elevation, draw f o perpendicular, o being the same height as the ridge, join o to d, then o d is the length and inclination of the hip, and the bevel at A is the side or plumb cut for the top end of the hip ; B is the bevel for the foot. It will be noticed that the hip is much flatter than the common roof, whilst a is level or at the eaves, c is at the same level as the ridge, having a rise equal to a common spar, in order that it may be in the same plane not only as the side but also as the end. When a roof is inclined for both sides and end, the pointed gable is done away with, the roof is said to be hipped; a line of intersection being formed where the sloping side and the end meet.

This line of intersection a c is the plan of the hip, and being common to both end and side it is the only line that is wholly in both planes, as it is both in the plane of the end and also that of the side.

Fig. 2. Represents a section of the wall plate and spar or common rafter, when the spar terminates at the edge of the wall plate. If the spars be cut out as at o they are said to be birdsmouthed.

Fig. 3. Shows the spar projecting over the wall plate, the spar being shown by the outline a b, c d, to the same pitch as the roof above. When the spar projects in this manner it is desirable to reduce the portion of the hip that projects over the wall plate to correspond in depth with the ordinary spar at a b, which is a line common to both. From points a and b draw the dotted lines a e and b f, these lines are drawn to the true inclination of the hip, (and obtained as at Fig. 1.) then o p is the real depth of the portion projecting over the angle. This depth varies according to the pitch of the roof. It will be found that o p is greater than the depth of a common spar, because the perpendicular a b, being common to both, the hip is much flatter than the common roof or spar, therefore the depth is greater.

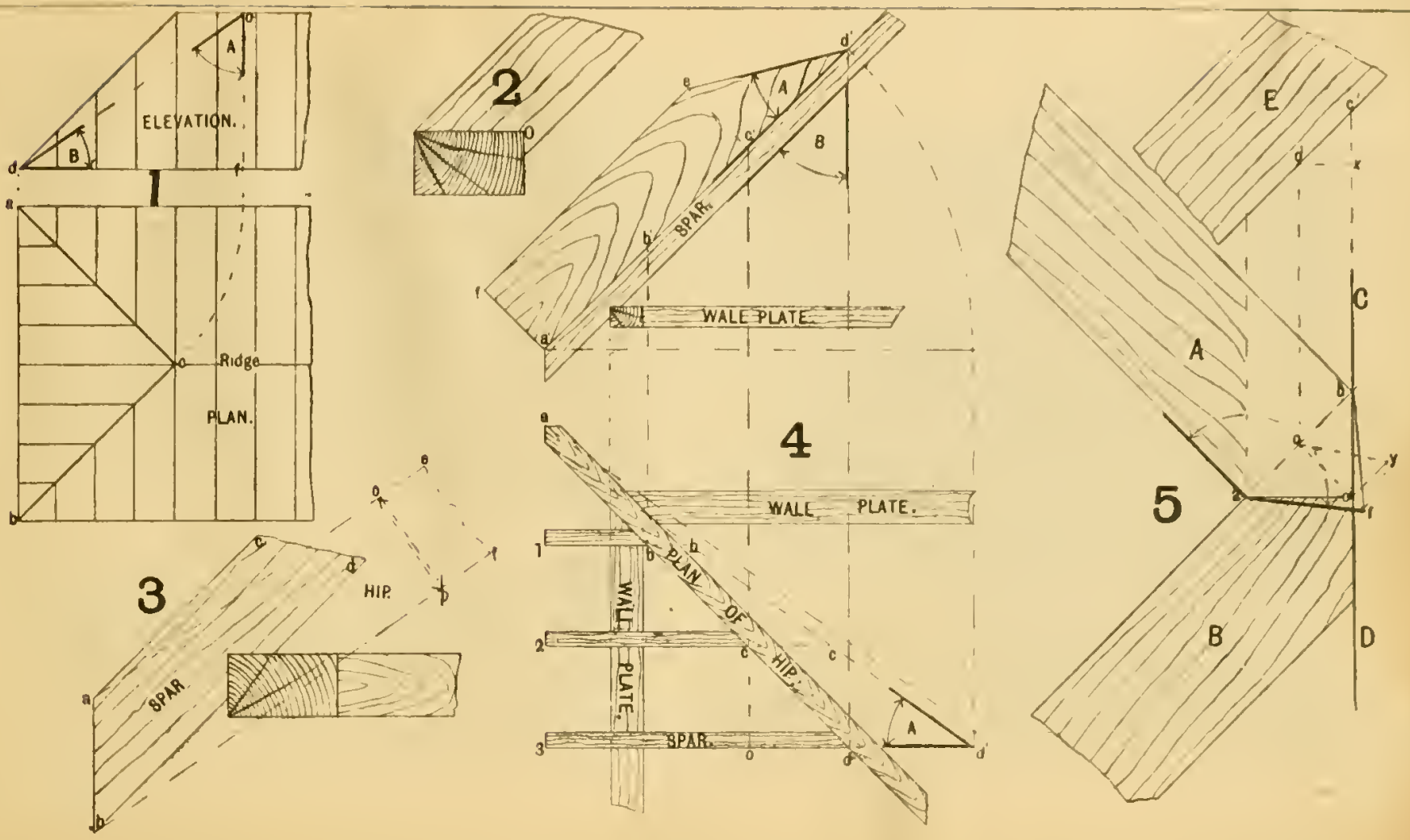
Fig. 4. Shows a section, and plan, part hip, and three spars. First let it be required to determine the true length of the spars 1b, 2c, 3d, (these are known as jack rafters, being so named when the common rafter is cut against a hip, valley, or between a hip and a valley,) from the points b, c, d, where they cut against the hip in plan, erect perpendiculars until they cut the top of the spar in points b′, c′, d′, then a b′ is the length of the shortest spar a c′ the second and a d the third, the length is measured from the top edge of the spar, (the bevel for the bottom must be allowed for.) This is based upon an elementary problem in geometry previously explained, viz., that any line or plain figure drawn upon a plane parallel to itself is shown its full length or size.

The plumb or side cut is shown at B, and the edge cut at A, to find this in the plan with a as centre, and any length a d′ as radius, turn a d′ horizontal, and determine d″ in plan, join a to d″ and the true length of the hip to d is obtained and the side bevel A for the spar is determined. If the long edge of each spar be projected as shown, then the same length will be obtained as was the case by projecting into elevation, the lengths in plan are shown 3d″, 2c″, 1b″. The edge cut may be determined by projecting the width of spar into elevation, and developing the edge as shown at a d′, e f, in order to show this clearly, a good width should be taken in plan, and the same used for the top edge. In plan the distance from o to c has been used as the thickness of the spar, then project c and d in elevation, from c′ draw c e at right-angles to a d′, and equal to the thickness used in plan, draw the line d′ e, this determines the required edge cut, and is the same as the bevel A shown in plan. The full top edge is also shown, but is not necessary. By comparing them it will be found that the angle A in plan and A in elevation are both alike. The bevel may be found by either method, whichever is most convenient.

Fig. 5. A and B shows the plans of the hips mitred together and cut by the line C D as by a ridge, king-post, &c. The edges are taken square, draw the line a b, then all that is required is to find the true shape of the triangle a b c ; a b shows the true width of the hip, it only remains, therefore, to find the true length of the line o c, draw a part of the elevation as shown at E, project o c, and o′ c′, is the elevation of o c, make c y, equal to x c′, then o y is the true length, and mark it off from o to f, join a f, and b f, and the true shape is obtained. The bevel that fits against C D is similarly determined. The side cut of the hips is shown at A Fig. 1.

Exercises.

1. The plan of a roof is an equilateral triangle, draw it and determine the cuts for spars and hips.
2. In Fig. 4 show the full elevation of the hip, that is, its edges as far as the broken line.
3. Show the true shape of a hole made in the roof by a vertical circular pole 6″ in diameter.
4. If the roof be boarded with 1″ boards, show the edge and side cuts of the boards, at the hips.


ELEVATION.
A
B
1
Ridge
PLAN.
2
SPAR.
WALE PLATE.
4
WALE PLATE.
PLAN OF HIP.
WALL PLATE.
SPAR.
3
HIP.
SPAR.
5
E
A
B
C
D

BEVELS FOR ROOFS—*continued.*

Fig. 1. Shows a sectional elevation and plan of a hipped roof, angle tie, wall plate and purlin. First draw the plan of the wall plate, angle tie, &c., as shown; the top edge is left square, and the end is cut square in plan as shown at o p. To get the elevation, draw the line o'a at the required inclination, and a line from p in plan to p' in elevation. This is on the same level as o'; from p' in elevation draw the dotted lines parallel to o'a; this completes the top edge of the hip. To draw the bottom edge, let the purlin and rafter correspond in depth to the depth of hip, so that the common rafters and hip may be level on the top side, and the purlin and hip on the bottom. The purlin is seen in cross section, and a line parallel to the bottom edge of the purlin (which is also parallel to the top edge of the hip) is drawn; this represents the bottom side of the hip, its full side being from a to c; c to d shows the bottom edge. The purlin is shown in elevation as it would appear when projected into the vertical plane, the dotted section showing where it would cut against the further side of the hip.

To draw the plan of the angle tie so that the bottom edge of the hip may be level with the underside of the angle tie and form a good abutment. In the present case the wall plate and angle tie are the same thickness and shown level top and bottom, half-lapped, and dovetailed together. (The angle tie is often kept higher but the same rule applies.) As they are to be level, produce the line c to the underside of the wall plate at n, drop a line from n in elevation to n in plan, on the near side of the hip, then draw the angle tie at right angles to the plan of the hip, set off the width, and the position, &c., of the angle tie is determined. If the angle tie be kept nearer the corner than this rule indicates, the bottom edge would run below it, but if kept further from the angle it reduces the depth of abutment.

Fig. 2. Shows how the hip is cut to fit the wall plate and angle tie. The plan has been removed from Fig. 1, in order to make room for the section. Let the angle tie, wall plates, and hip rafter be drawn as at Fig. 1.

In order to show the necessary cuts, draw a section upon a vertical plane, this is taken parallel to the plan of the hip on x y. Draw the wall plate and the angle tie as seen in sectional elevation Fig. 2, and make the perpendicular heights n m, the same as n m Fig. 1, then o is in a line with the top of the wall plate, join m o, and the pitch and depth of the hip is obtained when a line through n is drawn parallel to m o. For the depth of the hip end over the wall plate make o z Fig. 2, equal to o z Fig. 1, then draw a line from z parallel to m o until it cuts the wall plate; this gives the depth or end of hip. In order to determine the true shape of the underside to fit the angle, find the true shape of the triangle a o b near A, see plan, project these points to the top side of the hip, and develope these upon the top edge, square a or b upon the opposite edge, o being in the centre, this is the true shape from which the bevels are taken, the shaded portion a o b c d, shows the underside cut to fit the angle tie and wall plate.

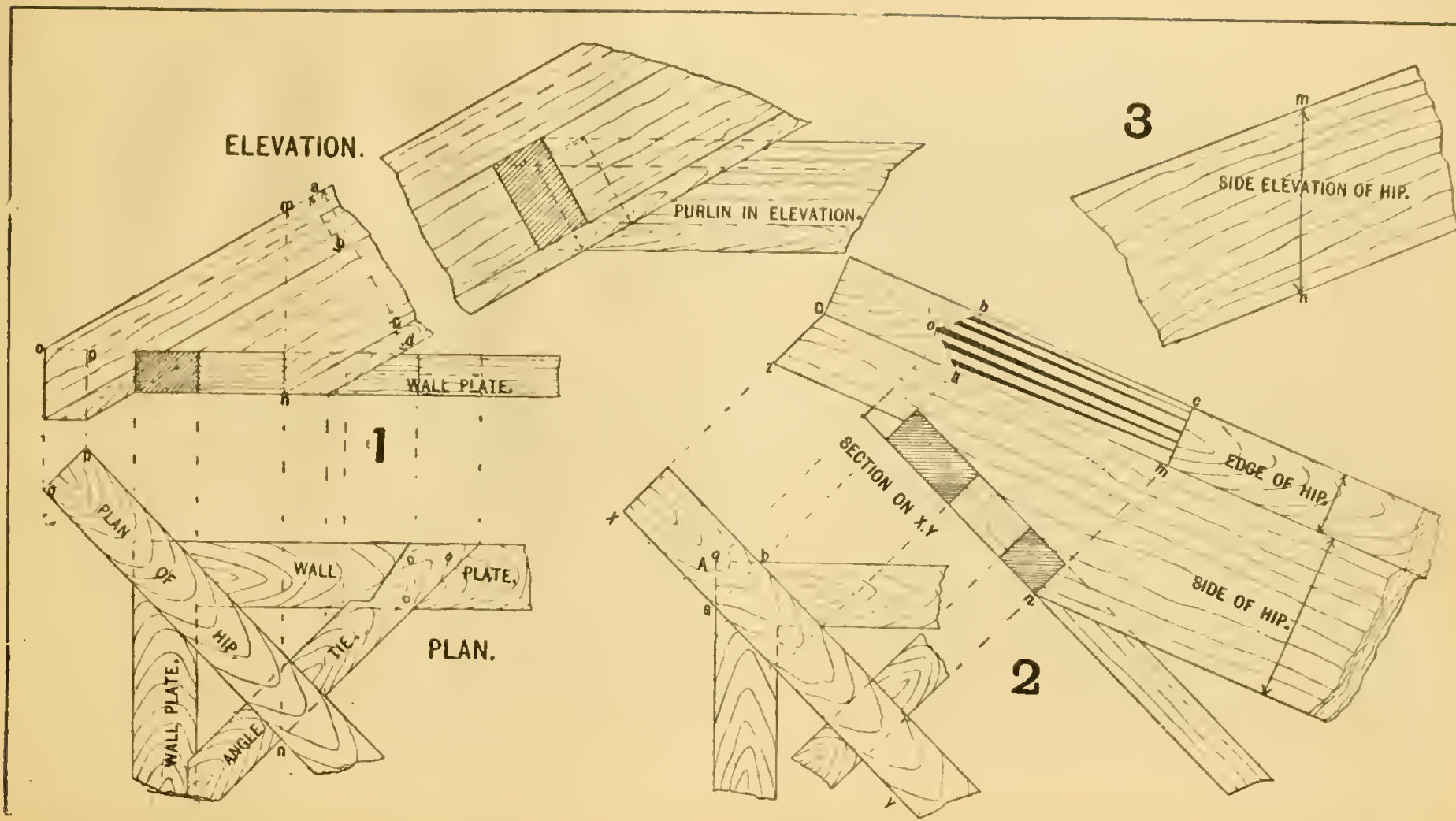
The reason for showing these cuts developed upon the top edge, when in reality they are for the bottom edge, is for convenience.

Whatever be the thickness of hip used in plan, the same thickness must be used when developing the edge. If a hip cuts into the angle, *i.e.*, if no angle tie and dragon piece be used, then the bevels are the same as those last determined, and parallel to them.

Fig. 3. Shows how to determine the true depth of hip when it has to be level top and bottom both with the spars and purlin as just described. At any convenient place draw the perpendicular m n Fig. 3, equal to m n Fig. 1, determine the pitch of the hip and draw lines through m and n at the true inclination of the hip, the distance between those parallels shows the required depth of hip.

Exercises.

1. Draw plan of the purlins where they cut against the hips. Determine the true shape of the purlin end.
2. Let the wall plate and angle tie be 3″ thick, and 1″ notched out of each, show how much further this will remove the angle tie from the corner, keeping both hip and tie level on the underside, as shown at n, Fig. 2.
3. The plans of two hips form a right angle, the surface of the end is 45°, and the points measured along the wall plate 12 feet apart, show the true shape of the surface of the roof.
4. A square brick chimney shaft rises through the roof; a diagonal being parallel to the ridge, show the development of the roof surface. Scale and other conditions at pleasure.


ELEVATION.
PURLIN IN ELEVATION.
WALL PLATE.
1
PLAN OF WALL PLATE.
WALL
PLATE.
HIP.
TIE.
ANGLE
PLAN.
SECTION ON X.Y
2
3
SIDE ELEVATION OF HIP.
EDGE OF HIP.
SIDE OF HIP.

HIP, ANGLE TIE AND DRAGON PIECE

Fig. 1. Shows a section and plan of a hipped corner, where an angle tie and dragon piece are used. The hip is not shown in plan as it would tend to confuse the drawing. The pitch of the roof is taken at 45°. The foot of the hip is prepared in the same way as the foot of a principal rafter; the angle tie is 6″ × 4″, and notched upon the wall-plate; in the corner the dragon piece is notched out to get a solid bearing, see drawing, if the wall-plate be flush with the outside of the wall, the angle tie cannot be notched over as shown. The projections are clearly shown, and will be understood by referring to the drawings.

Fig. 2. Is an enlarged section showing the joint between the angle tie and dragon piece, this is the same kind of joint as is used for securing a trimmer and trimming joist together, and fully described when treating on the single floor.

Fig. 3. Shows how to find the cuts for the edge of hips when they are backed; *i.e.*, used in dressed roofs, when one half lies in the plane of the side and the other in the plane of the end. Let a and b represent the points where the hips spring from, and c, the point where they meet in plan, H, the pitch of the roof; set the distance m n along m c to o, join a o and b o, these last lines represent the true length of the hips, and the angle A is the mitre line for the edges. The length m n is turned down upon m c, produced by using m as a centre, and m n as radius, (see the arc n o). This is an easy and correct method for determining the length of hips, valleys, &c., but when skylights have to be framed, it is necessary to develope the ends or sides in this or a similar manner, in order to get the true shape and bevels. The plumb or side cut is found by determining the true pitch of the hip.

Fig. 4. a, b, d, e, represents the wall-plates, a c and c b the plan of the hips, c f the ridge, the end a b c being much quicker pitched than the sides. When the hips are left square on the edge, it is necessary to keep the hip to one side, in order that the edges of the hip may be at the proper places for receiving the top end of the spars. To find the right position for fulfilling the above conditions, let a, b, e, Fig. 4a, represent the outside edges of the wall-plates, and v w the thickness of the hip, a line as o n at right-angles to the plan of the hip must cut the two wall-plates one in each edge of the hip, o n is equal to v w, and any line at right-angles to the side is horizontal, and as the wall-plates are perfectly level the two points o and n, one on each wall-plate, will represent two points in the hip, one on each edge; draw through o and n lines parallel to the plan of the hip (a c Fig. 4), these denote the position of the hip.

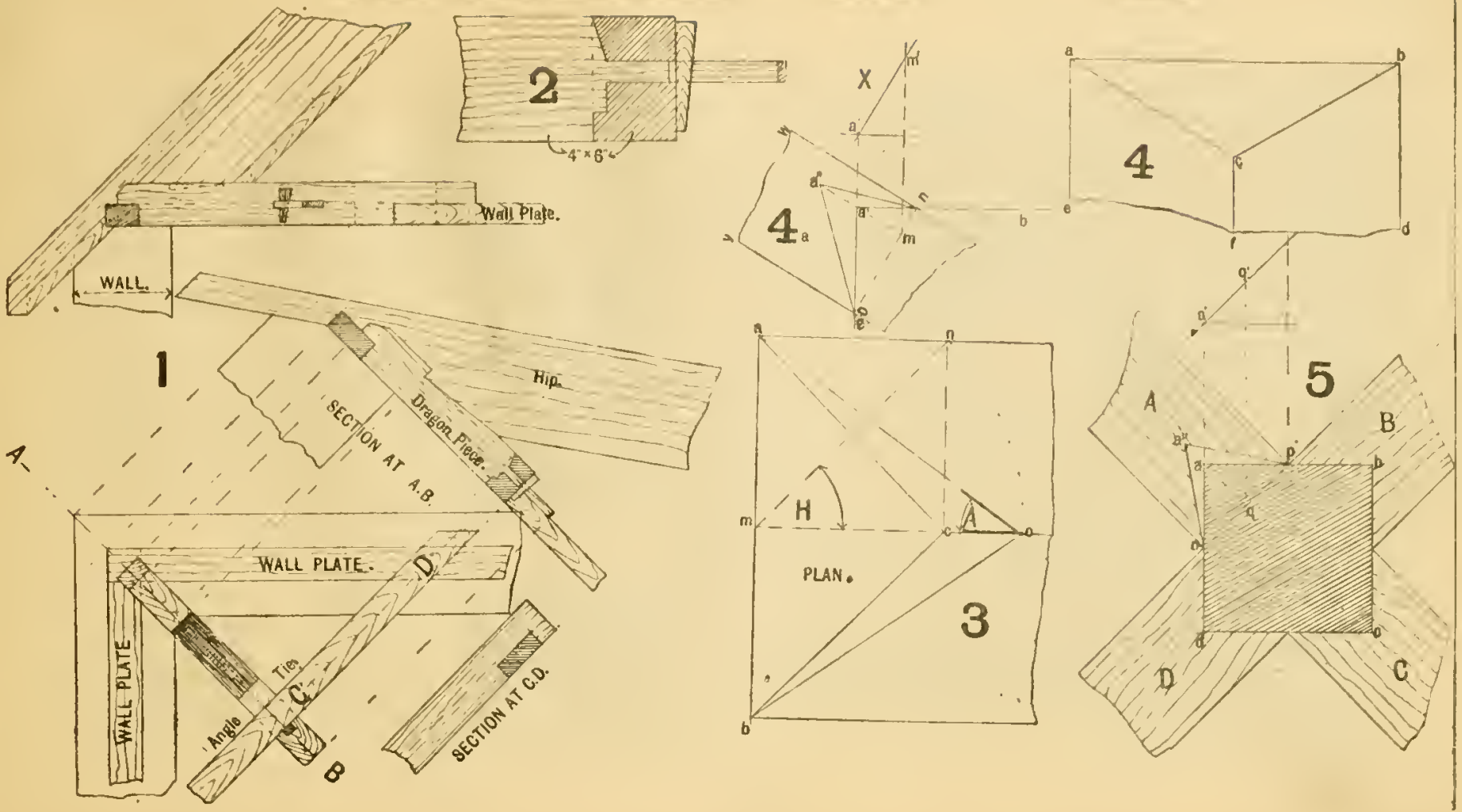
To determine the cut for the piece projecting over the wall plate, where it fits against it at o, a, n (see Fig. 4a), join o n and make a m at right-angles to it, then find the true length of a m. Let a′ m′ at X represent the pitch of the side and project a and m from the plan to a′ m′ at x, then a m is the plan of a line a′ m′ its elevation, determine its true length, (by any of the methods already explained); make m a″ equal to the true length, join a″ to a and n, and the necessary bevels are determined.

The pitch of the roof plays an important part, but all that is necessary is to project points into the elevation, from the plan, and proceed as explained. It will be observed that this is determining the true shape of the triangle o a n Fig. 4a.

Fig. 5. a b c d, shows the plan of a square finial or king-post; A, B, C, D, the plans of four hips cut against the corners. To determine the bevels for the edge of the hip A where it fits the angle, the two sides cut the finial at o and p, find the true shape of the triangle o a p, proceed as at Fig. 4a, q a is the plan, q′ a′ the elevation of a line, mark its true length on the line q a produced to a″, join a″ to o and p, and the necessary bevels are obtained; the other three are the same, and the plumb or side cut obtained in the usual way. If the finial had been turned until the square had been at right-angles to the plan, then the edge cut would have been square, and only the plumb cut to determine.

Exercises.

1. If the sides of the roof (Fig. 4), be inclined 45°, determine the pitch of the end.
2. Determine the true length of the line a m, a′ m′ Fig. 4a.
3. Let the hips in Fig. 4 be 9″ deep and 3″ thick, inclination of roof 45°, suppose the hips to be let into the king a little, show the piercing made in the king-post; one side will be sufficient.
4. Show the backing for the hips in Fig. 4, *i.e.* the profile angle between the plane of the end and side. Scale and other conditions at pleasure.


1
WALL.
Wall Plate.
Hip.
Dragon Piece.
SECTION AT A.B.
A
WALL PLATE.
D
WALL PLATE
Tie.
C
Angle
B
SECTION AT C.D.
2
4" × 6"
X
4a
3
H
PLAN.
4
5
A
B
C
D

HEXAGONAL AND VALLEY ROOFS.

Fig. 1. Shows the elevation and plan of an hexagonal roof hipped to a point The same principle applies to this as to a square plan. To find the true shape of a side as a b v. turn the side a′ v′ shown in elevation into the plan, (see dotted lines,) this is the length of the sides measured along a centre line as n v, set off this length from n to v″, make it equal to a′ v ; join v″ to a and b and the true shape of the sides is determined. If the hips are backed the line for mitreing them together is also determined ; see angle a v″ n. If the roof is to be sparred in the ordinary way, it likewise shows the edge cut for the jack rafters. To find the true or profile angle, known as the backing of a hip, take a cut through the hip square to the plan, and elevation, find the true length of a hip say c v, make v v‴ equal to the height, join v‴ to c, and the true length and inclination of the hips are shown ; from any point as o take o z square to the pitch of the hip and from o mark a point on c v equal to the distance o z, join this point to b and d, and the true angle or backing is shown. (See sectioned part.)

Fig. 2. Shows the plan of the hips (from Fig. 1) mitred together ; draw the line o m square to the side of the hip, and find the true length of the line m n, or o n. B is the edge cut for the hips, A being the plan. The full length of m n, or o n may be found by any of the methods already explained. The plumb or side cut is shown at Ia, see angle v v‴ c.

Fig. 3. Shows the ridges, wall-plates, and valley rafter, for two roofs of different pitches. The plan of the intersection is found by drawing a line from where the ridges meet, to the outside point where the wall-plates intersect ; let the wall-plates be parallel to the ridges. The plan of a valley is found the same as the plan of a hip for different pitches, and is such that a line drawn square across the plan of the valley will cut each ridge in the edges of the valley. (See points 1 and 2.)

Two spars or jack rafters are shown, one on each roof ; the flat roof is inclined at 30°, the pitch of the small roof is found by making the rise from the wall-plate to the ridge, the same as the large roof. To find the side cut for the short spar, see E, take perpendiculars from the points 3 and 4 in the plan until they cut the pitch at E ; make the width equal to the width used in the plan, square across from 4 until it cuts the opposite edge in point 5, join points 3 and 5 and the edge cut is complete.

The edge cut for the other spar is obtained by the same method, square 3 over to 5, join points 4 and 5. (see F.)

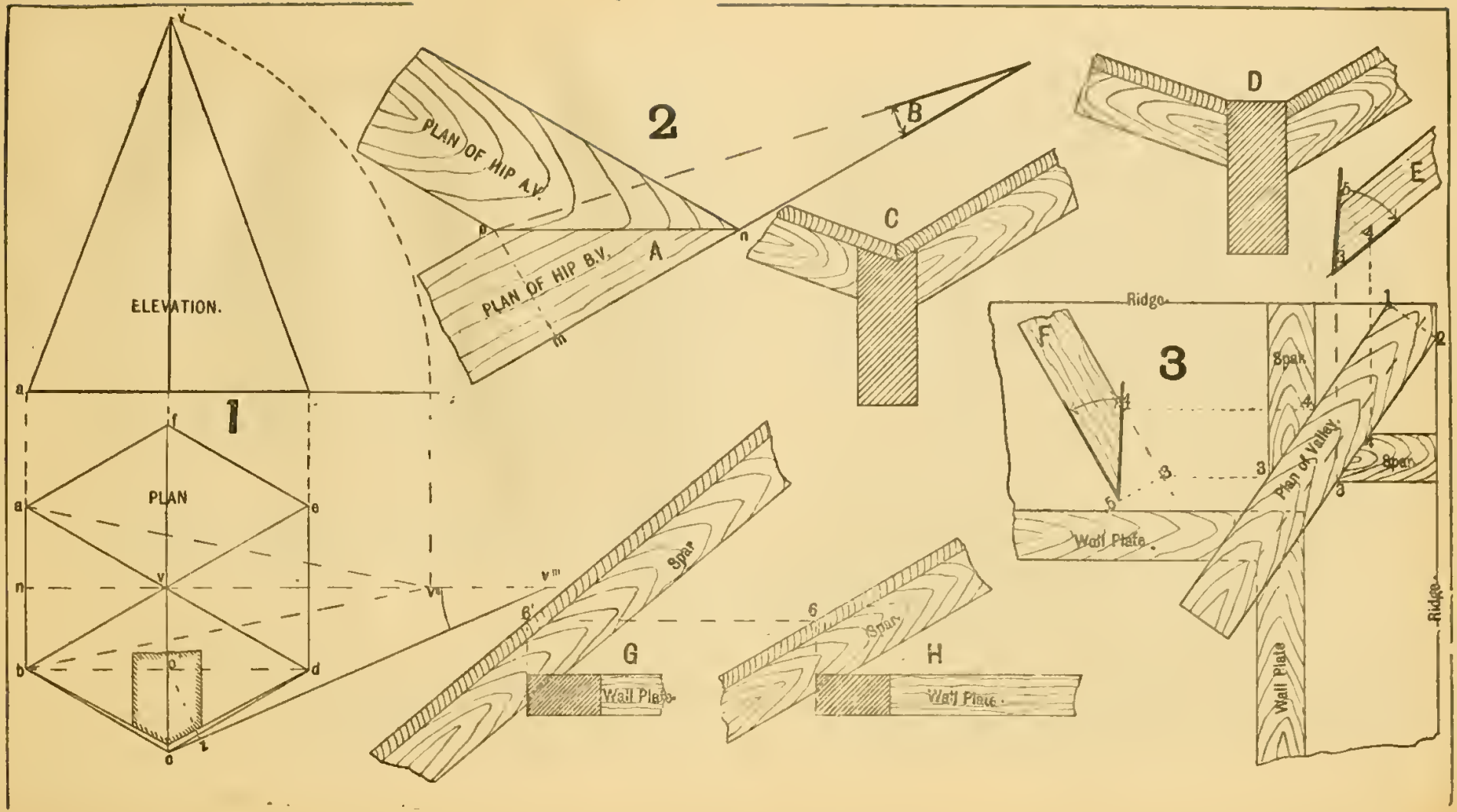
C shows the valley bottom prepared for the lead when the gutter boards are mitred, the boards being about 7″ wide and I″ thick. The above method is not in favour with plumbers, because it has a sharp corner in the bottom. This is remedied as far as possible as follows, let the top edge of the valley be kept sufficiently above the rafters, to receive the thickness of boards used in the valley ; then a flat space in the centre of the gutter is formed equal to the thickness of the valley-rafter, see D, where a section of the valley, spars and boards, is shown. In this two corners are formed but they are much more obtuse than the one at C.

To determine the true shape of the angle, the same rule applies as the one used for the backing of hips. If hip or valley tiles be required this would give the true shape.

In order that the valley boards may be level with the edge of the valley, the spars or jack rafters must be kept below the edge of the valley, to allow for the thickness of gutter boards. G and H show how this is obtained. Let the one at H represent the roof at 30°, showing spar, wall-plate, and valley board. Then to determine the necessary notch in the spar for the quick pitched roof, draw the wall-plate on the same level, and from the corner of the first erect a perpendicular cutting through at 6, then make the point in each the same height above the angle, as 6 and 6′. From the point 6′ G, draw the pitch of the roof, depth of board and spar, the depth of notching is shown. The cuts for the valley rafter are on the next plate.

Exercises.

1. Show how to determine the plan of the valley similar to Fig. 3, the thickness may be taken at 4″.
2. Remove the hip A Fig. 2, and draw an elevation of the other hip upon a vertical plane parallel to the line o n.
3. If the roof Fig. 3 be boarded parallel to the ridge and eaves, show both side and edge cuts for the boards on the small roof cutting against the valley rafter.
4. Show the development of a valley tile as above, 7″ each side from the angle, the top and bottom edges to be in line with the regular courses of tiles.


ELEVATION.
1
PLAN
2
PLAN OF HIP A.V.
PLAN OF HIP B.V.
A
B
C
D
E
F
3
Ridge
Span
Plan of Valley
Wall Plate
G
H
6'
Span
Wall Plate
Ridge

VALLEY RAFTER, AND A GROINED ROOF.

Fig. 1. Is a plan of the valley rafter &c. shown on the last plate, and reproduced to show the cuts for the valley ends. The ridges, wall-plates, and plan of valley rafter are marked and will be fully understood by a reference to the plate. For the valley the section is taken at the side a b and projected upon a plane parallel to it (see side of valley), the rise is taken from Fig. 1, 1 and 2, and set upon a b from 2′ to 1, join 1 to a corresponding point 1 through a corner of the wall-plate, then the pitch and length of the valley are seen. The plumb cut, notching on the wall-plate, and depth are shown on the side elevation, the piece sectioned at the top end of the hip is where it cuts against the ridge. To find the necessary bevels, develope the edge, and project each point upon it as shown. For the top end it will be seen that the centre of the valley does not run into the corner ; this is owing to the two different pitches, set off the same distances shown in plan c, c, make x c on the edge equal to x c in plan, join o c and o 1, and the bevels for the top end to fit against the ridges are determined. To make the bottom end clip the wall-plate the points are taken exactly the same way, each point being projected from the plan, for the inside the points are 1, o, 3, and for the outside they are 2, o, 4, the points o and o inside and outside are not the same distance from the edge; the length of projection over the wall-plate is arbitrary, and is shown cut short for convenience.

The same figures are used for the edge that were used in plan, and the bevels clearly shown.

Fig. 2. Shows how to obtain the profile angle for the valley, similar to the backing of a hip, R, R represent the ridges, W, W the wall-plates, v the plan of the valley rafter ; at any point o in m n draw the line a b equare to m n, and produce the two wall-plates to meet this line, see dotted line W a and W b, make n p square to m n, and equal to the rise of the roof, join p to m, and the length and inclination of the valley is shown. From o draw o z square to p m, and turn the line o z upon m n from o to x, and to that point join a and b, and the true shape of the angle is obtained. If valley boards are to mitre or fit against the side, this method of determining the bevels will be found to answer well, the small piece shown in section requires turning round.

Fig. 3. Shows a plan of a groined roof, the plan being a square, as used for turrets, &c. A section is shown, and the hips in plan but not projected into elevation, the section shows two common rafters.

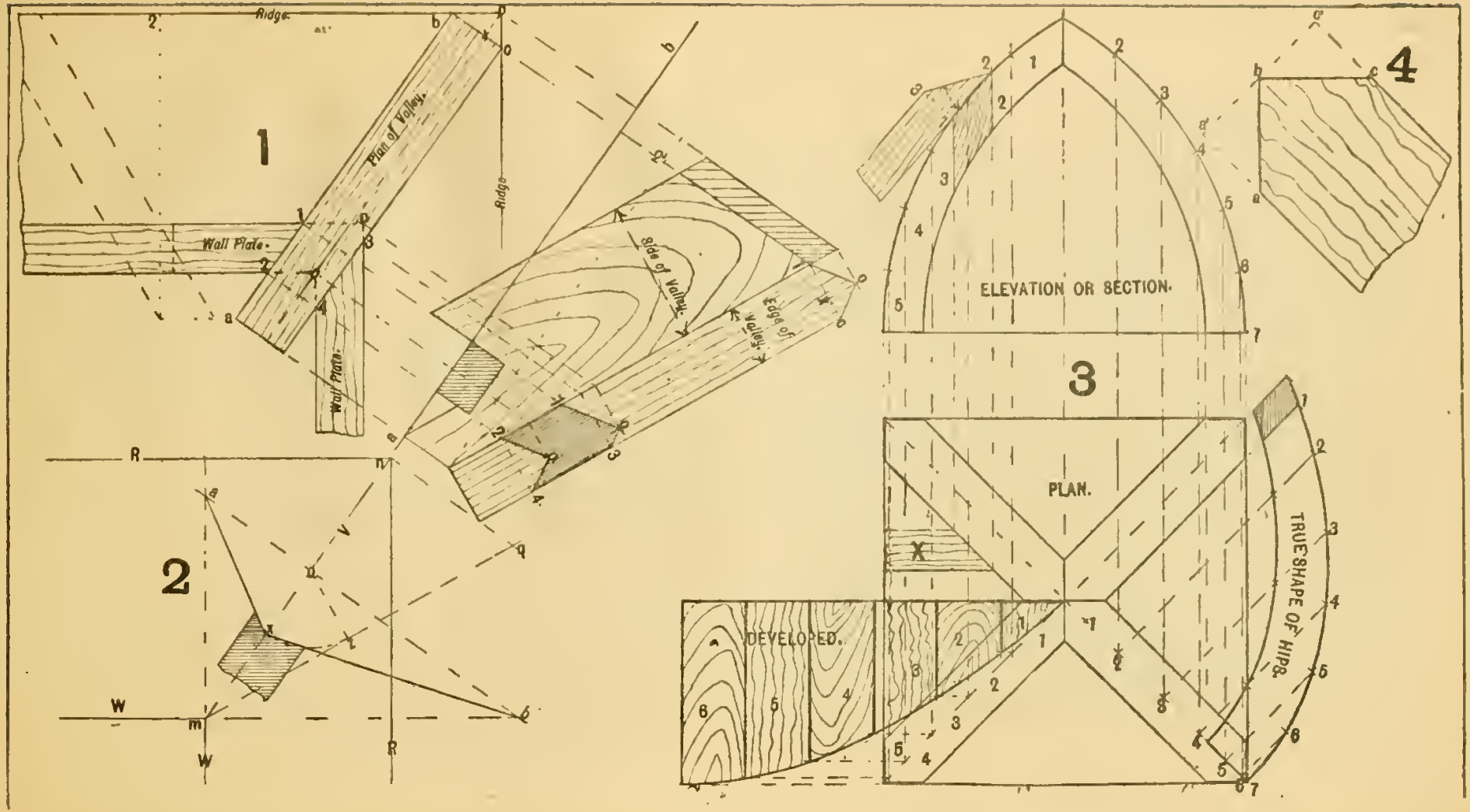
These roofs are usually covered with boards then lead or zinc for a final covering, and finished at the apex with a finial, &c., according to circumstances or taste. On the right-hand side of the plan the true shape of a hip is shown, the heights are taken from the section and figured 1, 2, 3, &c., the centre of one of the hips in plan is taken as the springing line for the rib ; this will be easily understood by referring to the figure, the portion sectioned is where they mitre together at the top. On the left-hand side of the plan a spar or common rafter X is shown projected into elevation, which shows its true length, the shaded part indicates where it cuts against the hip, this shows the plumb or side cut for a spar at that point. To get the edge cut: join points 1 and 2 by a line, and draw a line parallel to this line and at a distance from it equal to the thickness used in plan, from point 1 draw the line 1 to 3 square until it cuts the opposite side of the top edge, join 2 to 3 and the edge cut is determined. After marking the plumb line, let the other be squared over and a line drawn on the other side, join those by a line as 1 to 3, and the bevel may be dispensed with ; care must be taken that whatever thickness X, or the plan may show, it must be carefully copied, to get the correct bevel. Only one rafter at X has been shown, but the length and bevels for the others are obtained in the same way.

The development of one-eighth of the covering is shown, this gives the length and curve for the board ends to mitre on the hip. The covering has been divided into six widths numbered 1, 2, 3, 4, &c., see plan and section ; the full stretch out in section has been brought into plan, it will be seen that all boards are shown full length in plan, and only require to have their proper widths set off from the elevation or section. A reference to the drawing will make this plain.

Fig. 4. Shows an enlarged plan of one corner, a c represents the thickness of hip, when the hips have been cut out square to a′ c′, in order to get the backing, the templet must be pushed forward from c′ to c and from a′ to a, mark this with your templet upon the side, it will show the amount to be taken off. This principle was explained when treating on angle brackets.

Exercises.

1. Show how to obtain the bevels for a valley rafter, both roofs having the same pitch.
2. Show how you would obtain the same angle or backing as **Fig. 2**, by using the wall-plates as ridges, and ridges as wall-plates.
3. Project the hip in Fig. 3, *i.e.*, show the elevation.
4. Show how you would obtain an approximate bevel for the edge of the boards (Fig. 3), they may be taken at 1″ thick.


1
Ridge.
Plan of Valley.
Wall Plate.
Wall Plate.
Ridge.
Side of Valley.
Edge of Valley.
2
R
W
W
R
3
ELEVATION OR SECTION.
PLAN.
DEVELOPED.
TRUE SHAPE OF HIPS.
4

BEVELS OR CUTS FOR A PURLIN.

When hips and valleys are very long, they are often met by one or more purlins, according to the length of spar required.

Fig. 1. Shows a section and plan of a roof, where the purlins are cut against the hip, the section of the purlin has its corners numbered 1, 2, 3, 4, and is at right-angles to the pitch of the roof. From the section in the vertical plane, let fall projectors on the plan between the two hips, these lines between the hips numbered 1, 2, 3, 4, show the true length along each corner of the purlin, according to the scale used, a short piece of purlin is shown on each side, which would run to a principal, wall, hip, valley, &c. When a purlin is shown in this manner, the necessary bevels are not seen in plan or elevation (they must be found), while the full length of each edge is clearly shown in plan, the width of edge and side are foreshortened and require to be developed.

Fig. 2. In order to show this more clearly, an enlarged section, and plan of one end has been drawn. Three corners of the purlin, are marked a, b c, and projected upon x y, this line x y represents the plan of the hip; the plan of the edge is shown by two parallel straight lines a a and b b and the plan of the side b c by b b and c c. From the manner in which the purlin is placed it will be seen that the edge of 5″ is represented by two lines further apart than the side which is 7″. The edge is cut off by the hip at a and b, a representing the longest corner and b the shortest. To find the bevel develope the edge, *i.e.*, set off from the edge b b a width equal to the thickness a b shown in section, draw from a the lines a a′ to cut the edge developed, join a′ to b and the edge bevel is determined. See bevel E. To determine the side bevel proceed in the same way, b is the longest edge and c the shortest, develope the side from the edge b b, *i.e.*, draw a line parallel to b b at a distance from it equal to the side b c in section, draw c to c′ in plan, join c′ to b and the side bevel is obtained. See bevel F. In the finding of these bevels it will be seen that when the first plan of the purlin is drawn, it is projected upon a plane parallel to the purlin, hence all corners are seen their full length.

Then it is only a matter of developing the edge and side, these are shown developed about the edge b b, this being most convenient. The plan in Fig. 1 is distorted to show where the hips and ridge meet.

Spars are usually nailed on the purlins as shown at Fig. 1, it is better to notch the spar a little and let it clip the purlin as at A, this prevents the spar from sliding, without depending wholly on the nail.

When purlins are arranged perpendicularly, as at B, a small piece is notched out of the spar to give a solid bearing. The true bevel for the edge of purlins placed in this manner is seen in plan, and the side cut is square from the edge.

Fig. 3. Shows an ordinary case of a small roof rising above the eaves of the main roof which it intersects. The eaves or wall-plates, ridge, hips, and valleys are clearly shown, the roofs being covered with 1″ boards, which are shown in front elevation on the main roof. Let it be required to develope the sides and end of the small roof. It will be seen by the elevation that the sides are inclined 45°, then from the ridge in plan set off the line 4″, 3″ parallel to it and at a distance equal to the length of sloping side as b′ 3′ in elevation, join a to 4″ and b to 3″ and the true shape of the side is determined. For the development of the end make 3 and b″ 2 and b″ equal to b 3″, then the triangle 2 b″ 3 is the development of the end.

The line a 4″ is the length of a valley, and the line b 3″ is the length of a hip.

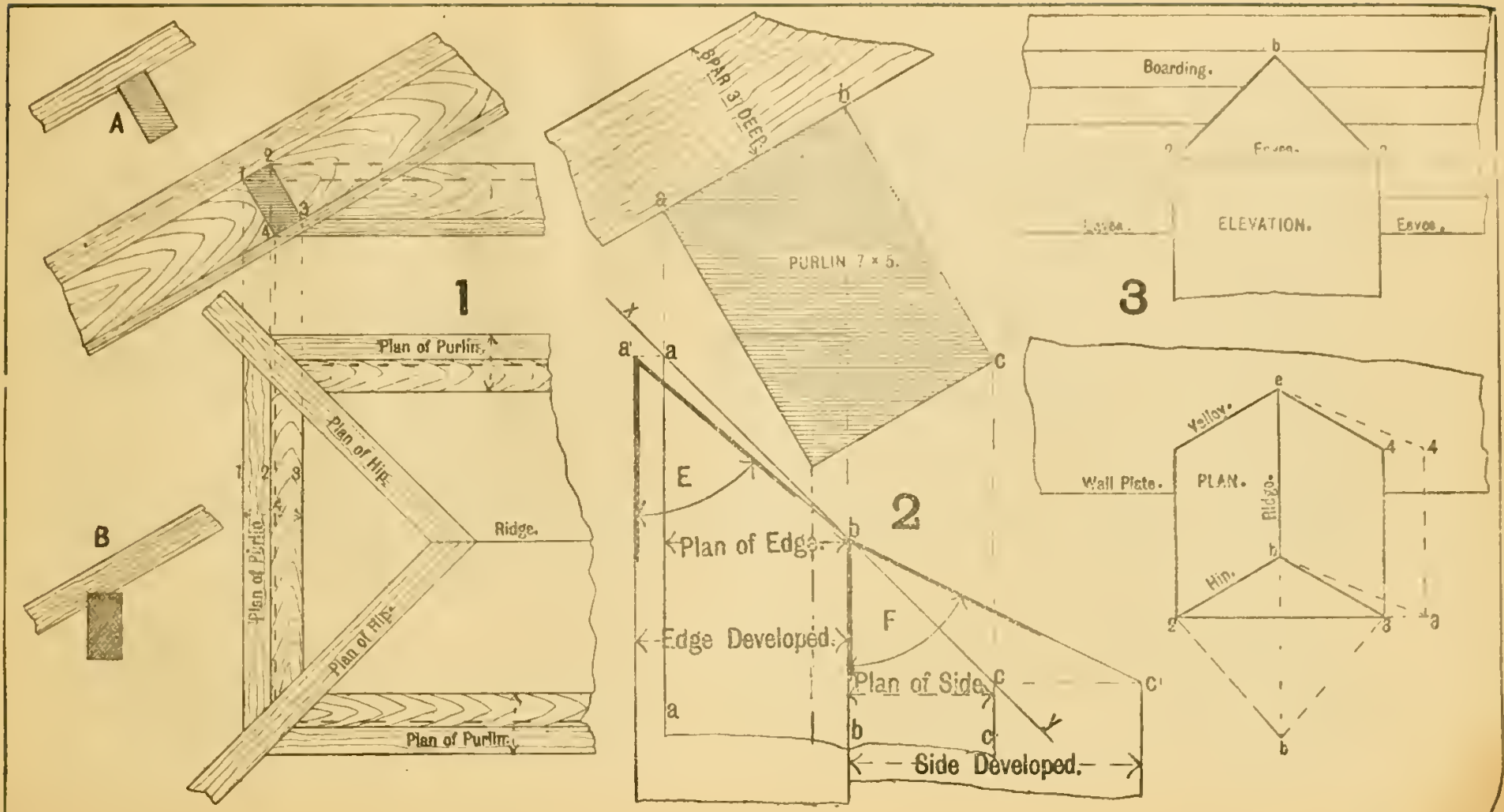
All bevels, side cuts, lengths, &c., for the boards are determined, and may be taken from the developments.

In framing skylights for conservatories, &c., these developments are necessary, in order to get the bevels for valleys into the bottom and top rail, bevels and length of bars between the hip and bottom rail, &c., &c.

Exercises.

1. Show the true shape of the covering for the main roof. Fig. 3.
2. Show how to determine the height of eaves for the small roof from the plan.
3. Determine the inclination of the main roof, also the front of the small one.
4. If a purlin cuts against a valley, the method of determining the bevels both side and edge is the same as for a hip.

Show a purlin in the main and small roof, and cuts for the same.


A
B
1
Plan of Purlin.
Plan of Hip.
Ridge.
Plan of Purlin.
Plan of Hip.
Plan of Purlin.
RAFTER 3" DEEP.
PURLIN 7 × 5.
2
E
Plan of Edge.
Edge Developed.
F
Plan of Side.
Side Developed.
3
Boarding.
Eaves.
ELEVATION.
Eaves.
Valley.
Wall Plate.
PLAN.
Ridge.
Hip.

FRAMED SKYLIGHTS, AND A VENTILATOR.

When treating on raking, angle mouldings, &c. earlier on, plan, elevation and section were given, showing how to determine the necessary moulds so that the hip, ridge, &c., might all mitre together.

Fig. 1. The present plate shows a section ½ full size through top and bottom rail of a framed skylight 3″ thick ; (part plan being shown at A,) B shows how the hips are mitred together. In section the ridge is shown, this is formed by mitreing the two top rails together. This may be finished with a roll, cresting, &c., to any pattern. It is best to groove the glass in as shown, and not rebate for it, the bottom rail is thinner to let the glass run over, and is likewise kept down a little for the lead flashing or to let out the condensed water.

In the present case a curb is shown grooved into the bottom rail ; if the ridge and hips be mitred as shown, it is advisable to put a cross tongue in the joint, as it keeps the joint level. The same mould is used for the bars as is used for top rails and the hip stiles, no raking moulds being required. The hips and ridge may each be made in a solid piece to the required shape, and the ordinary mould will be all that is necessary. The development of the end and sides, also the determining the length of bars, has been explained before.

This class of sky-lights is used over areas, staircases, hoists, &c., sometimes the curb is framed, and louvre-boards put in for ventilation.

Fig. 2. Shows a triangular louvre frame for a ventilator on a slate roof, these are used for stables, schools, churches, &c., in order to let out the heated air as it rises. It will be seen at a glance that such a frame with louvre, &c., like this is full of bevels.

Fig. 3. Is an enlarged view of Fig. 2; a, b, c, being the inside of the frame, or sides into which the louvres are trenched ; the section shows that the sill for the frame rests upon the spar, the slates finish against the sill, and a lead-flashing that passes over the width of the sill, is turned out upon the slates for a distance of at least 3″. A roll is shown at the apex.

The inclination of louvre-board and the distance apart vary with circumstances, but they ought to be so that rain would not be blown in during a storm.

To show as much as is necessary and not to confuse the drawings, only one louvre-board is shown in the front elevation, the louvre-board being shown cut off in a line with the front of the framing, and inside.

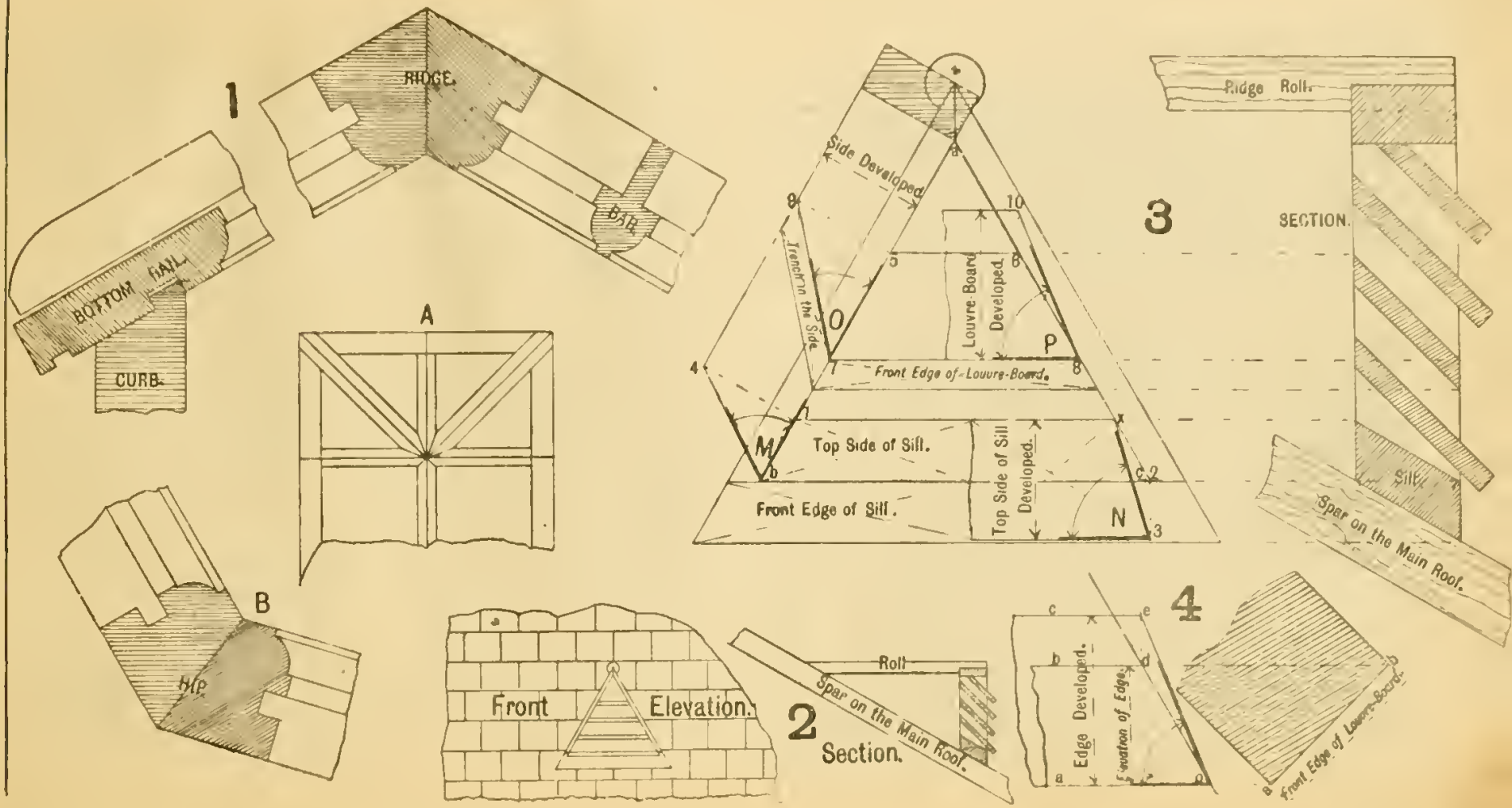
The sides a b and a c are grooved into the sill at the bottom end and mitred together at the top. In order to determine the true shape of the sides, develope the side, and from point 1 where the back of the sill cuts the side, square over from 1 on the front to 4 on the back edge, join 1 to 4, and the bevel M to fit on the sill is determined.

To determine the groove in the sill, from point 2 draw the line 2 3 square to the edge, point 3 is at a distance from the top edge of the sill equal to the width of the sill, *(i.e.,)* the top side of which has been developed; join X to 3 and the bevel N for the trench is obtained, note the length of the lines X 3 and b 4 must be equal. To determine the trench in the side for the louvre end (5, 6, 7, 8, show the louvre in elevation), from point 5 where the louvre runs out on the back edge, square over to point 9, join 9 to 7 and the bevel for the trench is obtained, and shown at 0. To find the bevel for the side cut of the louvre, develope the front or topside of the louvre-board as shown, draw a line parallel to 7 and 8, and at a distance from it equal to the width, shown by a line passing through point 10, draw a perpendicular from point 6 to cut the developed edge, which cuts it in point 10, join 8 to 10, and the side bevel P is obtained ; note lines 7 and 9, 8 and 10, must be equal in length. When developing the side care must be taken to use the same width that is shown in section.

Fig. 4. To determine the bevel for the edge of the louvre, draw a small piece a b of the louvre-board full size, project a and b into elevation as at d o, then o shows the long corner and d the short one. Develope the edge a b, make a c in elevation equal to a b in section, from d draw d e perpendicular to a o or b b, and where it cuts the developed edge in e, draw from e to o, and the bevel for the edge is determined. The face of the ventilator will be perpendicular as seen in section. Only one louvre-board &c., has been developed, because the bevels are all the same.

Exercises.

1. On the ridge of Fig. 1, place a 2″ roll, and draw a corresponding one for the hip.
2. Explain why the lines b 4 and c 3, Fig. 3, are the same length ; also the lines 7 9 and 8 10.
3. Draw the plan of the triangular frame, and develope one side.
4. Let the sides of the triangular louvre frame be boarded, the joints being parallel to the ridge ; determine the side and edge cuts of the boards to fit against the main roof. The boards may be taken at 1″ thick.


1
RIDGE.
BAR.
BOTTOM RAIL.
CURB.
A
B
HIP.
Front Elevation.
2
Roll
Spar on the Main Roof.
Section.
Side Developed.
Trench in the Side.
Louvre-Board Developed.
Front Edge of Louvre-Board.
Top Side of Sill.
Top Side of Sill Developed.
Front Edge of Sill.
3
Ridge Roll.
SECTION.
Sill.
Spar on the Main Roof.
4
Edge Developed.
Elevation of Edge.
Front Edge of Louvre-Board.

VENTILATORS *continued.*—

Fig. 1. Shows part elevation, plan, and part section of a small square ventilator on the top of a roof. These are used for stables, schools, &c.

They are generally formed by square vertical posts, the bottom and top rails being framed into them; the louvre-boards about 1″ thick and at an angle of not less than 45°, the top is generally hipped, and often made quite an ornamental feature in schools, churches, &c.

In Fig. 1, the trunk part is a square, see plan, the sides being parallel and at right-angles to the ridge. When placed in this manner, the elevation would appear as shown at Fig. 1, and the other view would be as shown in section; all bevels may be obtained from these projections.

If the ventilators be very small then the louvre-boards do not begin until the ridge, the small spandrels being filled in with boards, and flashed with lead.

Fig. 2. Shows plan, and B part elevation of a similar ventilator, the diagonals of the square base being parallel, and at right-angles to the ridge.

In order to project the elevation from the plan, draw a section through the roof square to the ridge line, showing the pitch of the roof as at C, then in elevation set from the ridge line, z o, equal to o a at C. Join a o, and the elevation of one half is complete "see B," on the right-hand side a development is shown, this is necessary to obtain the bevels for the ends of the sill against the post, also to show what the true bevel of the side is so that the sill may be parallel to the roof. It will be seen that a and b are two points at the same level; produce the ridge, and from the angle at z, make z b equal to the side o b in plan, join o b in elevation and the necessary bevel for the side is obtained. This will be easily understood as the line z o shows the extra lengt of post required to pierce the roof, a being the shortest corner of the short post, and o the longest corner of the long post, then by developing the side the true bevel is shown.

Fig. 3 Shows a plan and elevation of an hexagonal ventilating turret; a diameter of the hexagon being parallel to the ridge. (See plan). In elevation one side is projected in the usual way, the right-hand side shows a development or true shape; and when made after this style the turret rests on the roof.

The projection of the elevation from the plan is obtained in exactly the same way as the square one. Having given the pitch of the roof, show a small section as at D, project the angles a, o, b into this, and let v represent the ridge, then from the ridge in elevation make v o equal to v o at D; the distance of a, below the ridge is taken from the section, join a o and the points where it pierces the roof are determined. The side on the right-hand is developed upon the centre line, make this equal in width to a side as B, make b the same level as a, join o b and the necessary bevel for the side is secured. The height of these is of no consequence so far as the bevels are concerned. This method of developing applies to all canted sides, as dormers, &c., on roofs. One bay at B shows the posts parallel to the diagonal but this is not often done, as it gives a great deal extra labour in putting in the louvres and forming the shoulders. No louvre-boards are shown, as they will be understood.

When these ventilators are very large, four of the angle-posts are projected down through the roof, and trimmed into heavy timbers from principal to principal, &c.

Fig. 4. Shows a circular louvre frame, usually placed in gables of schools, &c.

The frame is shown in section, and part of the top in plan.

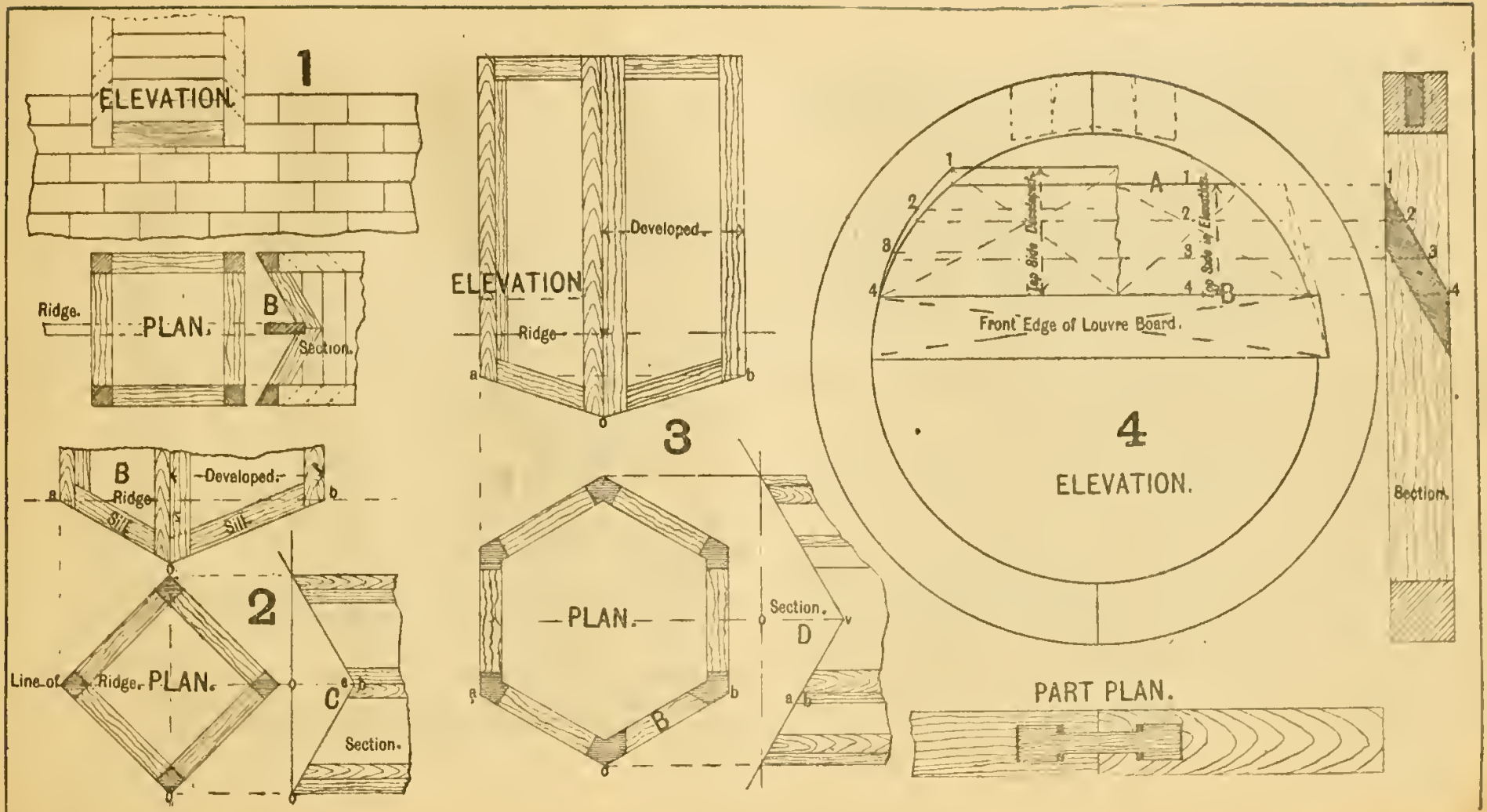
It will be seen that the ends of the louvre-boards are curved where they pierce the frame, this is shown developed on the left-hand side. The top-side of the louvre-board is shown, the short edge at A and the long edge at B. To find the curve take any number of points, as 1, 2, 3, &c. in section, and project these into elevation to cut the frame, then develope the top side, and raise perpendiculars at each point on the frame (see points on the left), then a curved line through these points is the line of intersection on the louvre.

They are generally cut through as shown on the right, the method of finding the side and edge bevels, applies as already explained, the objection to the curve being its great expense. Note the curve on the end varies in each louvre.

Only one louvre is shown, and this is cut off in a line with the frame; in practice they project at least 1″ in front of the frame.

Exercises.

1. In Fig. 2 show the trench in the sill or bottom rail, and the side and edge cuts for the louvre-boards. Pitch of roof 45°; pitch of louvre-boards 60°.
2. Show the bevel on the edge of the sill to fit the roof. (In Fig. 3).
3. Show the bevels on the sill to fit the posts, in the side marked B, Fig. 3.
4. Determine the necessary bevels for the louvres in the bay marked B Fig. 3. Pitch of louvre 45°.


1
ELEVATION
Ridge.
PLAN.
B
Section.
B
Ridge
Developed.
Sill
Sill
2
Line of Ridge.
PLAN.
C
Section.
ELEVATION
Developed.
Ridge
3
PLAN.
B
Section.
D
A
B
Front Edge of Louvre Board.
4
ELEVATION.
Section.
PART PLAN.

DORMER WINDOW & CUTS FOR VALLEYS.

Fig. 1. Shows a front elevation of a semicircular headed dormer in a slate roof, the dormer is shown boarded and covered with lead, and plastered in the inside. A section through the centre is shown, and the true shape of the curb developed. In the present case the curb is fixed on the spars and bevelled to the necessary angle for the boards on the outside, and on the inside for the lathe.

To develop the curb, draw any centre line parallel to the pitch of the roof and set off the distance, as a e, e a, same width of curb in elevation; project the points v C from the section, and draw the ellipses for the inside and outside of the curb. To obtain the necessary bevel for boards to lie on the curb, from O in section project to O in the development. Keep the shank end of templet parallel to the side, and slide the templet from v to O, mark the timber, and cut out to these lines. The bevel for the under side for a bed for the laths is obtained the same way. Joint at O C, and the surplus arrises or bevelled edge being taken off (see etched part), the curb is ready to fix.

The bead for the inside arris is obtained similar to this.

A vertical section through the head and sill and a horizontal section through one side, to a large scale, are shown.

Fig. 2. Shows a case where a semicircular headed window rises at the crown above the ceiling line a a. This occurs in churches at times, in the galleries. If a very cheap thing is required, then it is just bevelled out into the ceiling, the sides being vertical.

A front elevation and section are shown of a very common finish. From the crown O the bevel runs out at C on the ceiling.

Fig. 3. Shows to a larger scale how to obtain the curb for the arris where the coved head dies out in the ceiling. Make A A = to the width a a, Fig. 2, D′ O equal to d o, Fig. 2, and D C equal to the distance taken from the section. Divide D′ O into any number of equal parts in the points 1, 2, 3, 4, and 5; divide the distance D C into the same number of parts, and project from A to a, 1 to 1′, 2 to 2′, and so on to 5′; draw the curve through these points, repeat this for the other side, and the true shape of the arris to the cove made in the ceiling will be formed.

Fig. 4. Shows a plan and front elevation of a small gable roof requiring a couple of valleys.

Fig. 5. Shows a plan of the valleys and purlin to a large scale. Draw the section and project the purlin into the plan from points 1, 2, 3, and 4; from any point x draw the plan of the valleys, and draw the elevation of the valleys, as seen in section. The bottom side of the valleys is shown by the lines 6, 4, 8 and 0; the top edge is shown by the line through point 5′, and the other arris is parallel to it at the distance O from the top edge. The method of projecting this was fully explained before.

To obtain the necessary bevels for the head of the valleys to fit the purlin, draw a side elevation of a valley to the correct pitch as shown. Make the depth 5′ to 6′ equal to 5 to 6 from the section. This gives the plumb cut. Make 5′ to 3′ equal to the same space in section. This gives the depth of the side of the valley to fit on the purlin to answer the depth of the 3″ spar. Make 3′ to 8′ equal to the depth O, see section, and produce this parallel to the top edge. This shows the depth on the opposite side of the valley to fit on the purlin. To obtain the side cut produce the valley to where it cuts out at a on the bottom edge of the purlin, erect the perpendicular e to e′, join e′ to 3′, and the side cut to fit under the purlin is determined; see the angle S. To obtain the edge cut, develop the edge, and from O in section, project this to O′ in plan, draw O′, O″ from this last point square over to cut the developed edge in r, join r to e′, and the edge bevel is shown at E. The dotted portion is the end of valley to fit against the purlin.

To obtain the mitre cut, draw from x to 6′, and from Y to the bottom edge, and square over to y′, and the mitre cut is obtained.

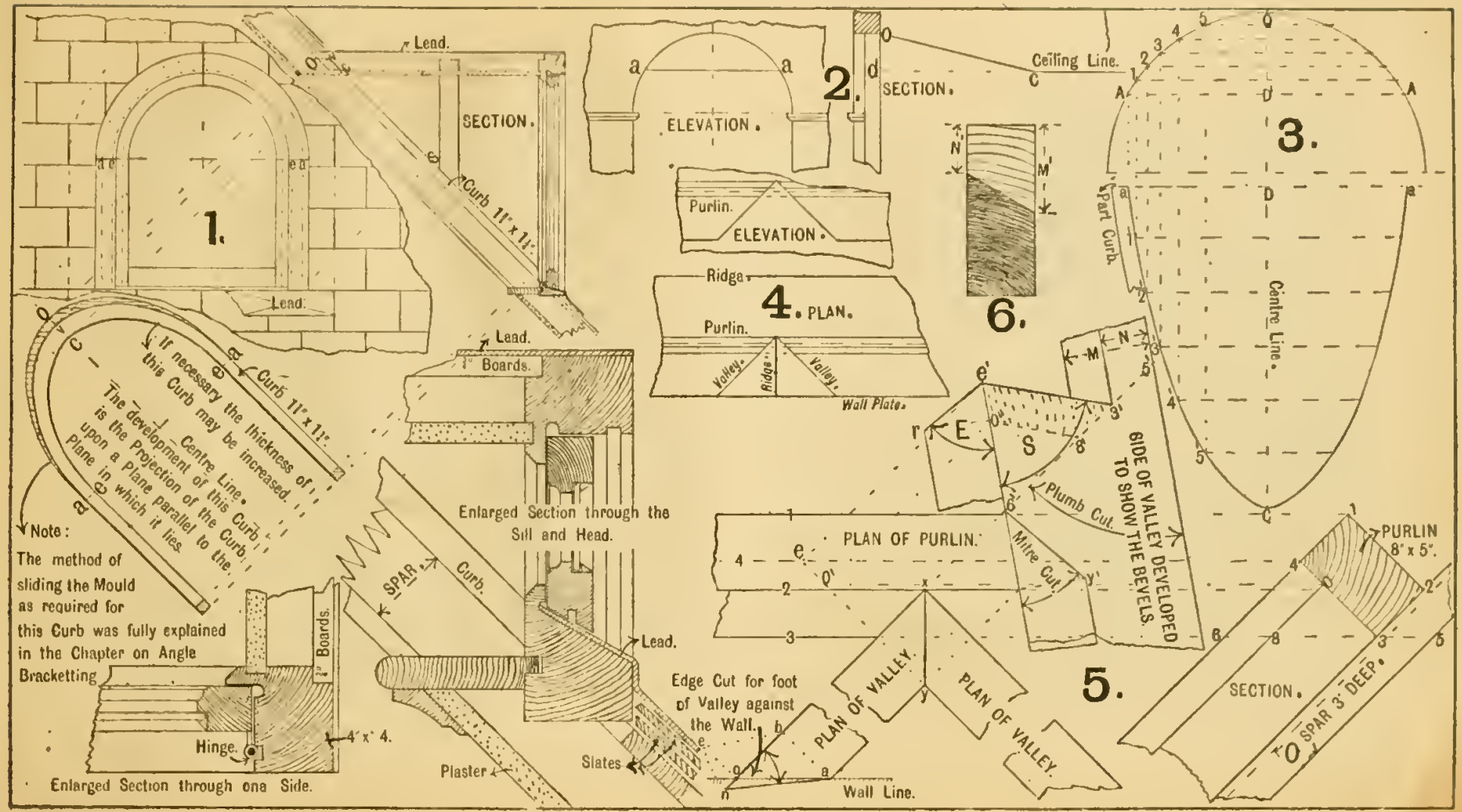
To obtain the cut to fit the wall at the bottom of the valley, a o is the wall line, draw a b and find the length of the line b o, this is shown at b e, make b n equal to b e, join a to n, and the edge cut is obtained. This part has been explained in a previous chapter.

Fig. 6. This shows the end elevation of the hip after it is cut to fit the purlin, and before it is mitred. Make M′ equal to M, and N′ equal to N; these are taken from the side elevation of the valley. The dark portion shows the piece cut back to fit the purlin. This cutting should be done before the mitreing and plumb cuts are made.

This method may be used for finding the backing for hips and valleys.

If the student prefers, he may find the backing for the valley by the method shown in previous chapters, but it will give the same result.

See cuts for Valleys pages 121 to 123.


1.
Lead.
SECTION.
Curb 1½" x 1½"
Lead.
Lead.
Boards.
Curb 1½" x 1½"
If necessary the thickness of this Curb may be increased.
Centre Line.
The development of this Curb is the Projection of the Curb upon a Plane parallel to the Plane in which it lies.
Note:
The method of sliding the Mould as required for this Curb was fully explained in the Chapter on Angle Bracketting.
Enlarged Section through the Sill and Head.
SPAR
Curb.
Lead.
1" Boards.
Hinge.
4" x 4.
Enlarged Section through one Side.
Plaster
Slates
2.
ELEVATION.
SECTION.
Ceiling Line.
Purlin.
ELEVATION.
4. PLAN.
Ridge.
Purlin.
Valley.
Ridge.
Valley.
Wall Plate.
6.
3.
Part Curb.
Centre Line.
PLAN OF PURLIN.
Mitre Cut.
Plumb Cut.
SIDE OF VALLEY DEVELOPED TO SHOW THE BEVELS.
PLAN OF VALLEY.
PLAN OF VALLEY.
Edge Cut for foot of Valley against the Wall.
Wall Line.
5.
PURLIN 8" x 5".
SECTION.
SPAR 3" DEEP.

STAIRS.

Stairs are a series of steps leading from one floor to another in a building, each step includes tread and riser, the tread is the horizontal part, the riser the vertical part, the raking pieces which support the ends of the steps are called stringe. The one next the wall, the wall-string or notch board; the other the outside, front, or well-string. When the steps are narrower at one end than the other, they are termed winders. The spaces wider than a step in front of doors or where there is a change in the direction, &c., are called landings, the succession of steps between one landing and another are termed a flight.

Planning and proportioning of stairs are generally matters for the Architect. It is not often that the joiner is called upon to choose the situation and make his own plan. Varied circumstances preclude any definite rules in planning, but they should be spacious, well-lighted, easy of access, and easy to ascend. There are many different methods of constructing stairs, depending on the character and use of the building.

Fig. 1. Shows the plan and sectional elevation of what is termed a doglegged or close newelled stair, the outer string of the upper flight being in the same perpendicular plane as the lower one, both are tenoned and housed into the same perpendicular post called a newel, as seen at the landing L in section. Newels are also placed at the foot of the stairs, and at the top or landing, to receive the rail. Newels sometimes extend from floor to floor and even up to the roof, generally they are sufficiently long to receive the strings and handrails with pendants underneath as seen at N.N.N.

Referring to the plan, the landing shown at L is what is termed a half space or level landing, the joists are framed as shown by the dotted lines. Had the landing been divided into two, by a riser placed from newel to wall at W, they would be quarter space landings; if it is necessary to introduce winders their narrow ends are housed into the newel.

Fig. 2. Is another plan of a newelled stair, the newels being separated by a short flight forming a rectangular well. Sometimes they are both on the same landing, with a short length of rail and balusters between them, these are known as open newelled stairs.

Fig. 3. Is the plan and sectional elevation of a stair with continued rail, the strings are joined by a curve in plan, that portion of the string that stands perpendicular over the curve in plan is termed the well, and the stringe being continued in a curve are termed wreathed strings, and the stairs geometrical.

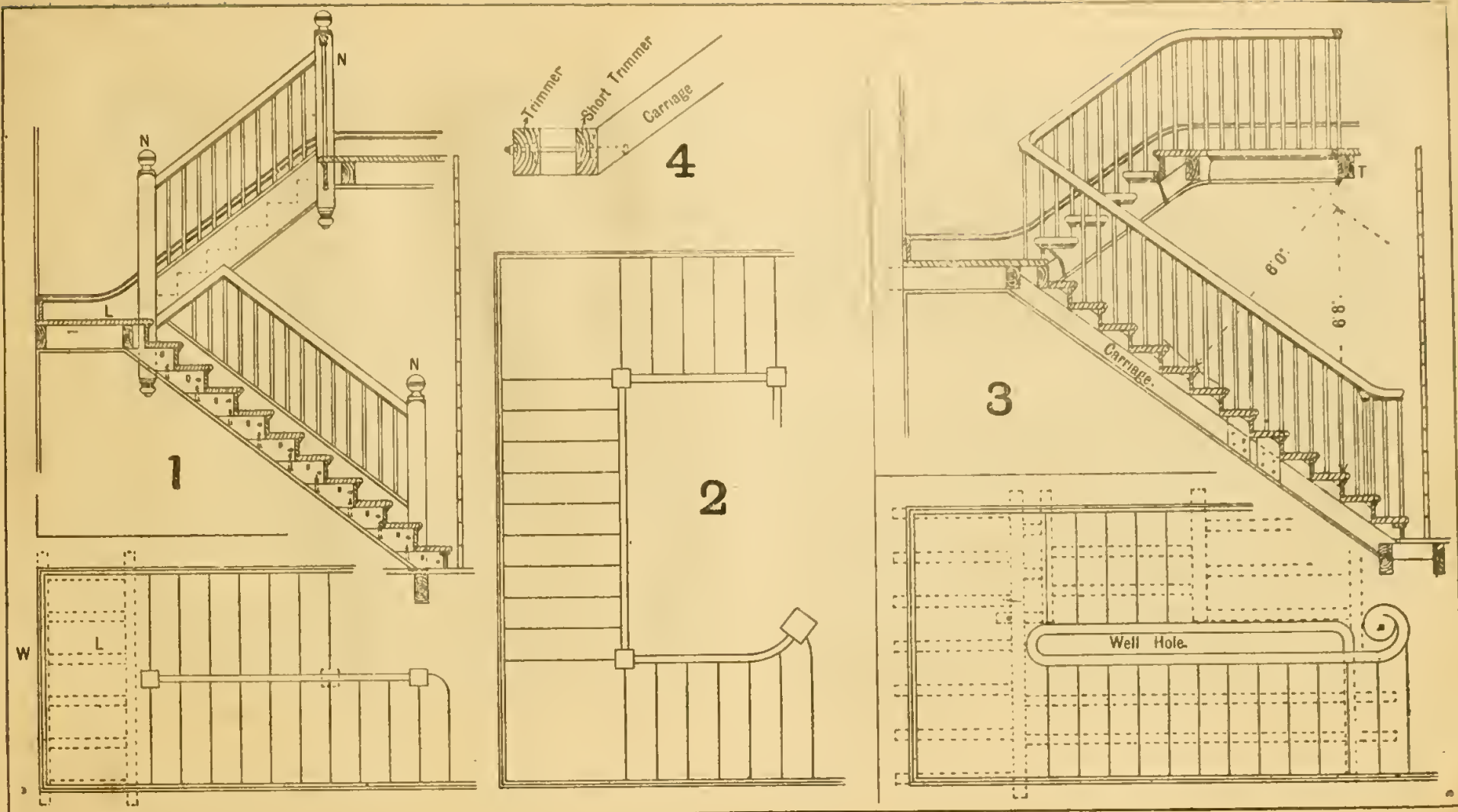
In this plan a half space landing is introduced with the joists and carriages shown by dotted lines. Carriages or spring-trees, are pieces framed to the landings, so that the back edge of each step will rest on them, they are usually about $5\frac{1}{2}'' \times 3''$ and to these are nailed the rough brackets. Referring to the section, it will be seen that a second trimmer is introduced to receive the carriage for the top flight.

Fig. 4. Is an enlarged section showing the trimmers and the joint with the carriage and trimmer.

In the old method of framing landings, the front trimmer or apron-piece was kept down to receive the carriages for the top flight, and the joists were cogged on to the trimmer, and allowed to run under the risers where the top flight begins, and to the back of the riser where the bottom flight lands. In many cases this caused the landing framing to be too deep, so that it is now almost superseded by the method shown.

Sufficient headway is an important condition in the planning of stairs, and at Fig. 3. is shown what Nicholson advises should be done to secure it. Describe an arc of a circle with a 6′ radius and the bottom edge of the trimmer as a centre, the nosing line must be kept clear off this to give ample head room. It will be evident by this method that stairs of a quick pitch would have an excess of head room measuring perpendicularly, whereas in stairs with a wide tread and small riser it would scarcely give sufficient. Take as an example, stairs with 12″ tread and $5\frac{1}{2}''$ riser, this method would give 6′ 7″ perpendicular height, measured from the nosing as shown in the section Fig. 3, where a height of 6′ 8″ is taken, through the point a line parallel to the nosing line is drawn, the trimmer should be clear off this line.

Easy ascent depends on the proportion between tread and riser. It is a well-known maxim that a broad step should be of less height than a narrow one. Generally a step with 12″ tread and $5\frac{1}{2}''$ riser is assumed as a guide to other dimensions. The two multiplied together equals 66, which is taken as a constant for the proportion, thus an 11″ tread should have a 6″ riser and so on; this is not often a matter of choice, but it may serve as a guide to guard against excess.


N
N
L
N
1
W
L
Trimmer
Short Trimmer
Carriage
4
2
T
6'0"
6'8"
Carriage.
3
Well Hole.

STAIRS *continued.*—

On this plate are shown methods of constructing the different parts of stairs.

Fig. 1. Shows the joints between tread and riser T, T, being the front and back of the treads, and R the riser, the portion projecting at N is the nosing.

When a mould S is placed underneath it is a moulded nosing, the projection varies but is generally about the same as the thickness of tread. The tread is grooved on the underside for the mould, to the required projection, the top side is grooved for the tongue on the lower edge of the riser, at a distance from the front edge equal to the projection and the width of tread given by the pitch board. The mould is glued and driven tight into the groove, the riser is then fitted to and kept at right-angles with the tread, glued, screwed, and blocked as shown, the riser is then gauged to depth given by the pitch board and the depth of the tongue, the step is then cleaned off and fitted into the notch boards.

Fig. 2. Shows part of a close string, in this case the string is trenched for the ends of the steps, this is termed housing.

S, S, S, is the string in section and elevation with two steps in section; T, T are the treads; R, R, the risers; W, W the wedges which secure the ends of the steps in the grooves. In stairs with close strings, bracketed carriages are generally used, under each step are fitted brackets as seen at B, C, these brackets are 2½″ or 3″ thick and are glued and screwed under each step about 12″ apart; each bracket is well secured to the one under the succeeding step, forming a continuous carriage to which the plaster laths or soffit boarding is nailed; they should be well secured to the landing framing; these brackets should have the longthways of the grain running in the same direction as the string.

Fig. 3. Shows part of a cut and bracketed string, in this case the string is cut to fit under each step, the tread and riser both project over the string, the tread projects the thickness of the bracket as shown by the dotted lines at B. But that portion of the riser that comes over the string, is reduced to the thickness of the bracket, and mitred at the end as seen at A, and where the stiffening blocks are fixed the risers are reduced for them as shown at A, these blocks are stump tenoned underneath the tread, and screwed to the back edge of the tread of the next step. At C the bracket is mitred to the end of the riser, the nosing shown as it appears when finished. At D the bracket is removed showing the iron baluster screwed to the block shown at A, and the ordinary baluster dovetailed into the end of the tread. At E part of the string S is removed showing the carriage and rough brackets with the end grain upwards, fitted underneath the tread and nailed to the carriages, glued, and blocked to the tread and riser. At F is seen the joint with the carriage and trimmer.

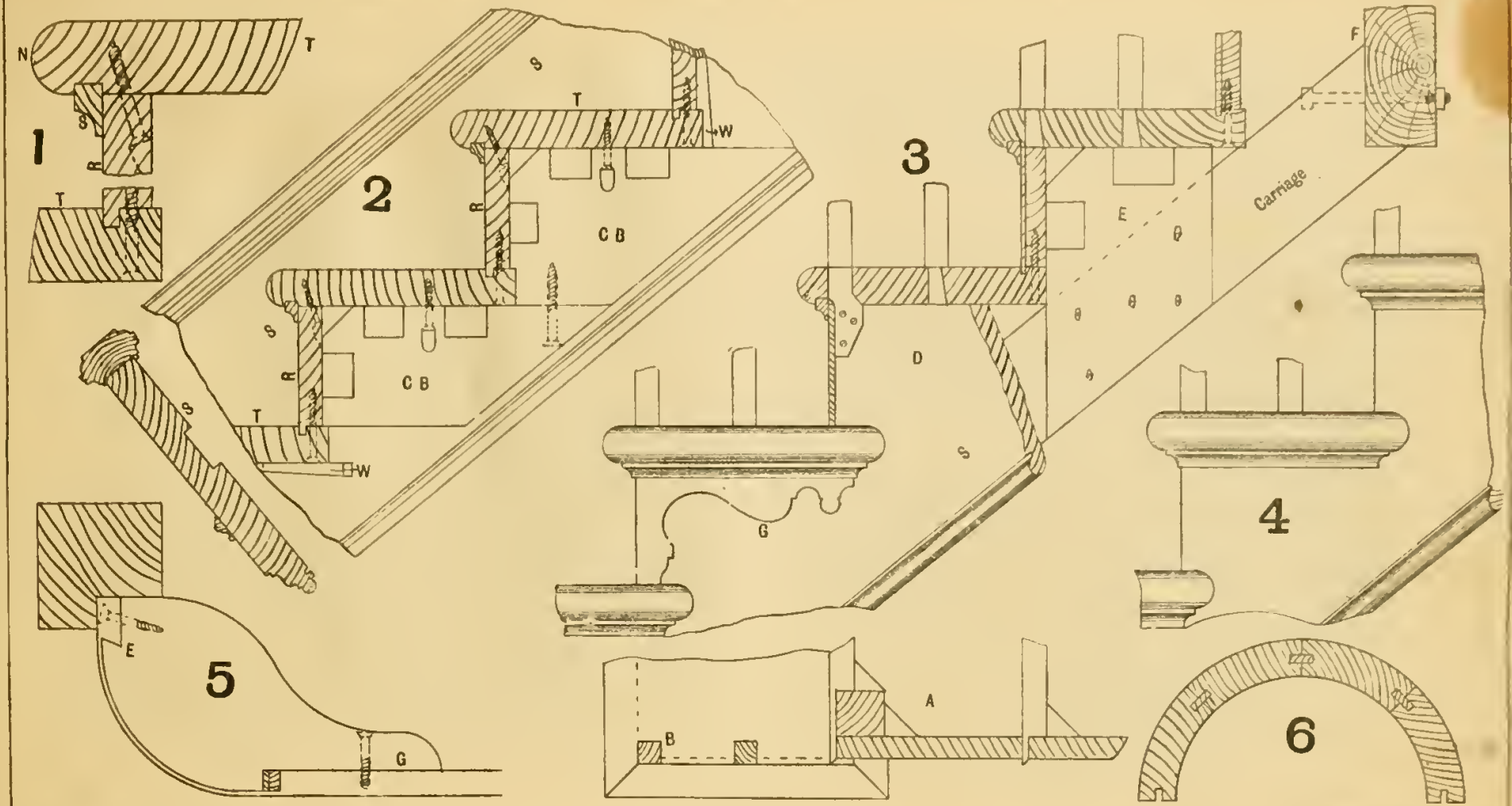
The ornamental brackets at the ends of the steps are generally made an inch longer than the width of the tread, given by the pitch board, so that the end of the bracket and the springing of the next succeeding one may be in the same perpendicular, and the nosing on the end of the steps mitred and returned round them into the string as shown at B.

Fig. 4. Shows part of a cut and mitred string, in this the string is cut to fit under the tread and to mitre with the riser, the tread does not project over the string with the exception of the nosing which is mitred to the return nosing on the end of the step, in other respects the construction is the same as Fig 3.

Fig. 5. Shows a riser prepared for a bull nosed step, the block is prepared according to plan in three pieces glued together, the grain being crossed, the block is reduced at E and F for the riser as shown.

A sufficient length of the riser is reduced to a veneer and cut to form a hook at E and allowing for wedges at F, when done the riser and block are glued and screwed at E, the block and veneer being glued the block is brought round, the veneer being firmly pressed to the riser, then the wedges are driven at F, when sufficiently tight they are screwed together at G.

Fig. 6. Shows a section of a staved well, glued up in convenient widths hollowed out to the required plan, the joints are grooved and cross tongued, before being fixed in its place all the joints should be well screwed at the back. This kind of well is not considered so good as a veneered well, but in many cases, where strings have much sunk moulding on the face, they cannot be dispensed with, without entailing a serious amount of labour.


1
N
T
S
R
T
2
S
T
W
R
CB
CB
S
R
S
T
W
3
F
Carriage
E
D
S
G
4
5
E
G
A
B
6

STAIRS—*Continued.*

In setting out stairs, a careful measurement of the staircase is made, the height from floor to floor and the position of trimmers &c., taken with a rod. From these dimensions a plan and section is drawn to a scale; 1½" to the foot, being most convenient, the treads and risers are divided to suit the plan and section, and set out on staffs and the pitch board made to the tread and rise given.

Fig. 1. Shows part plan of a stair with winders in one quarter, and a quarter space landing.

Fig. 2. Is the notch board for the top winders, to set this out the winders must be set out full size, with the notch boards and depth of housing. A staff is laid on the plan, in line with the face of the notch board; the face of the other notch board, and the point where rises 14 and 15 cut into the notch board are marked on it. Then on the notch board a line is drawn at a convenient angle with the edge, and on this line the distance from the face of the notch board to riser 14 is marked from the staff, then the pitch board is applied with the tread side to the line and to the mark made, draw the riser line, the pitch board is then turned round on the other side of the riser line and the next tread line drawn; on this line produced, the distance between risers 14 and 15 is marked, and the same operation is gone through with the landing step. A wedged shaped lath for the housing is held to the lines and the housings marked.

Fig. 3. Shows the notch board for the lower portion. A gauge or fence is made to the required depth from the top edge, the long edge of the pitch board is held to the fence as shown, and the tread and riser lines marked, then the pitch board and fence are moved forward, until the other end of the long edge of the pitch board touches the line of riser or tread, as the case may be, and the next tread and riser lines drawn, this must be repeated with all the straight steps.

For the first winder the tread line is produced, the distance between risers 12 and 13 marked on it. After the distances are taken the setting out is the same as for Fig. 2. At the face of the notch boards, lines are drawn at right-angles to the tread lines, one of them being marked for a groove and the other for a tongue as shown.

Fig. 4. Shows the outside string for the lower portion, a gauge is made to the depth of the carriage and soffit, and the pitch board is applied as for Fig. 3, the string is then cut out to the lines. Templets are made for the winders, allowing for nosing, riser at the back, and half an inch for depth of housing at the end.

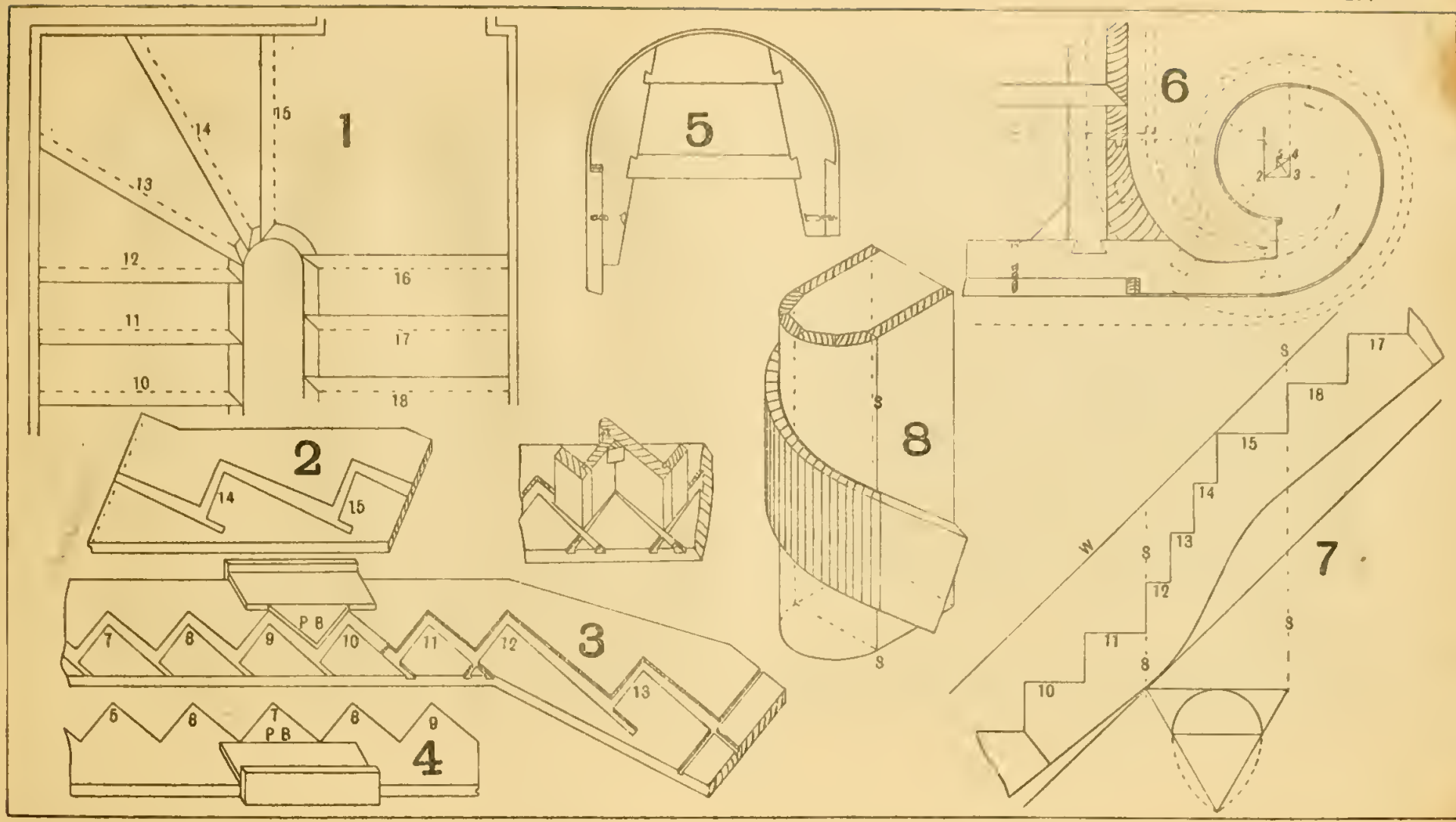
Fig. 5. Shows the riser for a round ended step, the block is prepared as shown, the other part of the construction is the same as for a bull nosed step.

Fig. 6. Shows the riser for a curtail step, in this case it is best to draw the scroll for the handrail first. (The balusters regulating the size of block as shown.) With point 1 as the first centre, and radius three times the width of rail, the first quadrant is drawn, make 1 2, two-thirds the width of rail, and with the reduced radius draw the second quadrant, make 2 3, at right-angles with it, and with three-fourths of 1 2, for the third quadrant, draw 3 4, at right-angles with 2 3, join 1 3, from 2 draw a line at right-angles to 1 3, to meet the line from 3 at point 4, for the fourth centre, at right-angles to 3 4, draw 4 5 to meet 1 3 at 5, which is the fifth centre, and so on; lines drawn at right-angles to meet the cross lines give the centres. The first radius and the reduction can be varied to suit any size of scroll.

Fig. 7. Shows the development for a veneered well for stairs at Fig. 1, the stretch out of the inside is obtained as shown, by constructing the equilateral triangle on the diameter, the two sides produced to meet the line drawn tangent to the circle and parallel to the diameter, the distance between the intersection is the stretch out of the semi-circle and the lines S, S are the springing lines.

In practice it is best to make a templet to the inside of the well, with the springing and the direction of the riser lines drawn thereon, then revolve the templet along the line, marking off each riser line, and perpendiculars from these points will give the riser lines in the development. Commencing at the first winder, the horizontal line drawn, gives the underside of tread of the last straight step, then mark off the height of rise, and another horizontal line drawn gives underside of the first winder, this is repeated until the whole are drawn, with two straight steps top and bottom; mark the same depth of string at top and bottom as Fig 4, draw the underside of the string and the distance between the parallel lines W, W shows width of stuff required.

Fig. 8. Shows the cylinder which has been made to fit the well. The springing lines on the veneer are kept to those on the cylinder, the well is fixed to the cylinder and blocks are fitted to the veneer and glued on, when hard they are levelled off and canvass glued on the back; after they are dry the well is taken off and cut to the lines.


1
2
3
4
5
6
7
8
P B
W
S

HANDRAILING.

The upper portion of the fence formed on the outside of the stairs is the handrail, to assist in ascent and descent of the stairs, and also for protection, it is evident the rail should follow the line of nosings, and at a height of 2′ 9″ to the top side of the rail from the tread at the nosing, measured perpendicularly in line with the face of the riser.

In the construction of handrails the chief difficulty is in the wreaths, where the rail is of double curvature, simple curves in either plan or elevation will cause no difficulty.

Fig. 1. Shows the plan of a rail for a level landing stairs, with the risers landing and starting in the springing, the radius of the centre line of rail, half the width of tread.

Having the plan and centre line drawn, the wreath being in two pieces, and one face mould answering for both pieces, to draw the face mould, first draw the joint line C D, then draw the tangent lines, A B being the centre line produced, and B D, at right-angles with the joint line, A B being equal to half the width of tread, the rail in coming up over this distance would rise the height of half a riser, causing the line B D to be horizontal; where one of the tangent-lines is horizontal it is at once used as the directing ordinate, then produce B D, and parallel with it draw lines from each side of the rail at D, and from the springing at A, draw X Y at right-angles to B C, and place the pitch board as shown against the riser line. Draw the underside of rail, set off half the depth of rail and draw the centre line, where it cuts the line from B D, will be the centre of the section on the landing, draw the section as shown and through the top corner draw V T from where the lines projected from the plan cut this line, draw lines at right-angles, on each of these lines mark off the corresponding distances in plan, measuring from X Y. Through the points draw A′ B′, C′ D′, and A′ C′, B′ D′, C′ D′, is the major axis line, and C′ A′ the minor, the lines on each side of D′ give the semi-major axis for the inside and outside curves for the mould, and on the minor the width of mould is the same as in the plan.

Draw the curves with trammel or string and pins, the shank may be made any convenient length.

Referring to the section at the line V T, it will be seen that if the arrises of the rail were required on, the dotted line through the bottom corner would give the least thickness that the rail could be got out of, and the dotted lines at right-angles to V T the width at the wide end. It will be seen that if the rail has to be got out of this thickness of stuff, to keep the proper height a slab will have to come off both top and bottom sides of the shank.

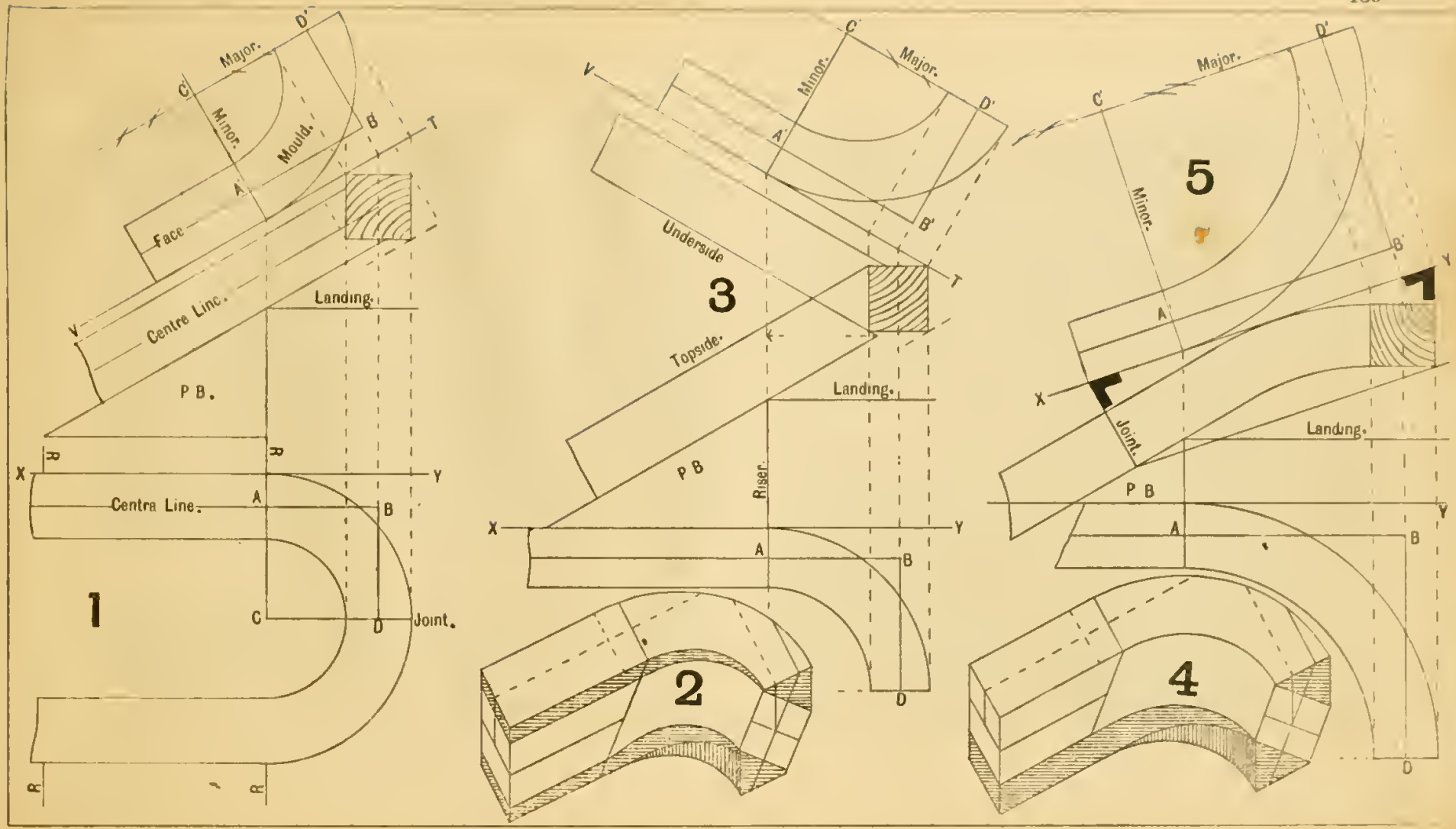
Fig. 2. Having cut the wreath out square to the size of face mould, allowing extra width at the wide end if required, the piece is planed true and the mould applied, and the tangent lines drawn on as shown by the dotted lines. The joints are made square to these lines, mark the centre of the piece at each end, with a bevel set to the long edge and riser side of the pitch board, draw the line through the centre, square over a line on each face from this line as shown, this gives the new tangent-lines and the distance the mould has to slide, the tangent-lines on the face mould are held to these lines, then mark for the stuff to be cut off, apply the mould on the other side and tack it on, working off the superfluous stuff to the lines and edge of the mould.

The figure represents the wreath worked into cylindrical form and ready for squaring, and the shaded portions show the slabs that have to come off. In practice this wreath is not easy to mould owing to the rise beyond the springing on the inside.

Fig. 3. Shows a better wreath. Draw the square section of the rail, and through the top corner draw the top side of rail for the lower portion, and through the bottom corner draw the underside of the top portion, draw lines to the depth of the rail, and from the intersection of the two undersides draw the horizontal line, and mark half the width of tread on it, measuring from the intersection. Through the point draw the perpendicular which gives the position of the risers landing, and starting, in this case they are in the springing of the well, project lines drawn from the springing and the section, to complete the plan; the face mould is drawn the same as Fig. 1.

Fig. 4. Shows the wreath piece cut out and worked into cylindrical form ready for squaring, the face mould being applied the same as in Fig. 2, the face mould gives the line for squaring the top off, and a better curve is obtained. It will be seen at Fig. 3 that the shank is not in the centre of the stuff, the shaded portion shows the slab to come off one side.

Fig. 5. Shows the face mould for a large well with the risers in the springing, project lines from the plan and draw the section at the proper height above the landing, draw the line from the underside of the section to meet the underside of rail coming up. Draw the line from the joint to corner of the section, this gives the inclination of the plank, and the parallel line on the top side the thickness; the bevel at X gives the butt joint, and the bevel at Y for sliding the mould. The face mould is drawn the same as Fig. 1.


Major.
Minor.
Mould.
Face
Centre Line.
Landing.
P B.
Centre Line.
Joint.
1
Underside
3
Topside.
Landing.
P B
Riser.
2
5
Minor.
Major.
Joint.
Landing.
P B
4

HANDRAILING—*continued.*

Writers on handrailing generally assume that the wreath is part of a hollow cylinder or such other solid, whose base is the plan of the rail; it is convenient to consider it such, for over the plan the rail must stand, and will be contained between the vertical sides of this solid, but wreaths being made from planks of wood, it will be evident, that the principle of handrailing depends on finding the section of a cylinder, or other solid when cut by a plane, determined in such position, in respect to the cylinder, or other solid, that the wreath will be contained between this plane and another parallel plane, with the least possible distance between them. The true form of the section is the face mould, and the parallel planes, the two faces of the plank. The two best methods of finding the section of a cylinder are as follows, *(a)* when three points are given, *(b)* the tangent system by Robt. Riddle, from whose book these few examples are deduced, and to his work the reader is referred for a further elucidation of the subject. By this system, the section is obtained by determining a plane to contain two lines that are tangent to the centre line of rail, given by their plans and development. These two lines will also be contained by two vertical tangent planes to the centre line of rail, those tangent planes being two faces of a prism.

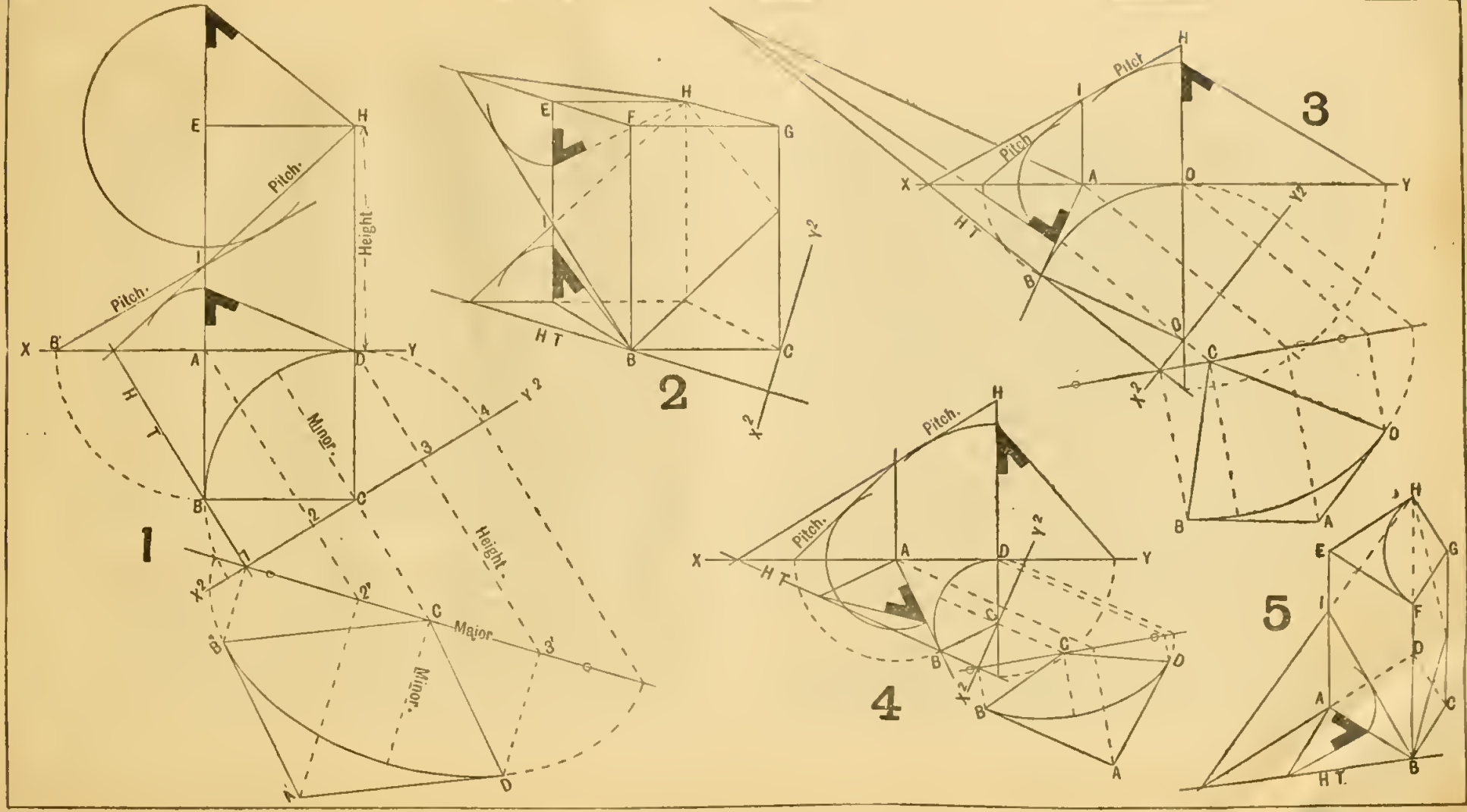
Fig. 1. The quadrant B D is the centre line of rail, A B, A D, are the tangent lines, the other two the springing lines B C and C D, which are at right-angles to the tangent lines, and meeting in the centre C, from where the centre line of rail is drawn. Then A, B, C, D is the plan of a square prism, two of its faces are tangent to the centre line, the other two are at right-angles to the tangent faces, and their intersection is the axis of the cylinder containing the centre line of rail; with the side A D, as a ground line draw an elevation of that face A D, E H, draw the line H I as the elevation of the line A D, and the pitch at which that face of the prism is cut, with A as centre, turn A B into the vertical plane; draw B′ I which is the elevation of A B, and the pitch that the face is cut by. To determine the horizontal trace of the cutting plane that contains these two lines, produce H I to meet the ground line which is one point in the H T, and B being in the horizontal plane is another point, draw H T through these points. Having the horizontal trace H T and the plan D and elevation H of a point, that the plane passes through, the inclination and section can be readily obtained. At right-angles to H T draw X2, Y2 through the centre C, by doing this the line that shows the true inclination will also contain the major axis of the elliptical section. Parallel to H T, draw lines from A C D, and on the line from D set up the height 3, 3′ taken from H D, then draw the line through 1, 3′ which is the true inclination of the plane, from 1, 2′, C′, 3′, draw lines at right-angles to 1 3′, then make 1 B″ equal to 1 B, 2′ A′ equal to 2 A, C′ minor to C minor, 3′ D′ to 3 D, join A′, B″, C′, D′, this is the section of the prism, and to be correct A′ B″ must equal B′ 1, and A′ D′, H I. To draw the section of the cylinder continue the centre line of rail to meet X2 Y2 at 4, draw 4 4′ parallel to 3 3′, then from C′ to 4′ is the semi-major axis, the semi-minor being drawn, draw the semi-ellipse which will pass through B″ and D′.

Fig. 2. Is a perspective view of the prism to assist the reader to follow what is done at Fig. 1, in order to obtain the necessary bevels, that is the angles the cutting plane makes with the vertical faces of the prism, A, B, C, D is the bottom face, and E, F, G, H the top face, and B I, H I, the pitches the two faces are cut by. Produce the upper pitch to meet the ground line or A D produced, through this point and B, draw the horizontal trace, to find the angle between the plane and this face, with A as centre draw a circle tangent to the pitch line and to cut the perpendicular A E, draw the line from the intersection to B, and in the angle is seen the bevel, B and D both being the same distance from A, see D, Fig. 1. Referring again to Fig. 2 it will be seen there is a second horizontal plane containing the top face of the prism and the pitch B I produced to meet the edge, F E produced is a point in the horizontal trace in that plane, and the dotted line through H is the horizontal trace, then with E as centre draw the circle tangent B I, and cutting the perpendicular A E draw the line from the intersection to H and in the angle is seen the bevel between the plane and this face; it will be seen that the bevel is found the same as at Fig. 1.

Fig. 3. Shows the tangents making an obtuse angle.

Fig. 4. Shows the tangents making an acute angle, the construction and lettering being the same as for Fig. 1, with the exception that both bevels are found on one horizontal plane. The bevels are found on the principle of finding the inclination of an oblique plane to the vertical plane of projection, given in all books on solid geometry.

Fig. 5. Is a sketch of the block given in plan at Fig. 4, to show more clearly how the bevel for the lower pitch is obtained.


1
2
3
4
5
Pitch.
Height
Minor.
Major
H T
X
Y
A
B
C
D
E
F
G
H
I
O
X²
Y²

HANDRAILING—*continued.*

Fig 1. Is the plan of a rail for a level landing, the risers landing and starting in the springing of the well, draw the centre line of rail and the joint line C D, draw the tangent lines A B, and E F, which are the centre lines of the straight parts produced, the line A E is drawn at right-angles to the joint line C D, and with the springing lines B C and C F forming two squares.

To draw the development of these tangent lines, with A as centre turn A B round, and with E as centre turn E F round, erect perpendiculars from B, A, D, E, F, then place the pitch board with the riser to the perpendicular springing line at B, and draw the underside of rail from where this cuts the perpendicular, draw the horizontal line (marked landing) where it cuts the perpendicular, from F set up the height of a riser. Place the pitch board P as shown and draw the underside of rail for the top portion, set off half the depth of rail at both top and bottom and draw the centre lines, where they cut the perpendiculars from B and F draw the horizontal lines, and through the points where they cut the perpendiculars from A and E draw the pitch across the well, through the point where this pitch cuts the perpendicular from D draw the horizontal line. The distance between these horizontal lines gives the height the rail rises in coming up from B to D, and from D to F. In this system the heights are taken from spring line to spring line, the shank ends are the tangent lines produced, which may be made any length.

To draw the bevels, with G as a centre on the horizontal line draw the circle tangent to the centre line and to cut the perpendicular from E, and from the intersection draw the line to H, and in the angles is seen the bevel for the shank end, then with I as centre draw the circle tangent to the pitch across the well and turn it round to cut the perpendicular above I, from the intersection draw the line to F, and in the angle is seen the bevel for the centre joint, set off half the width of rail on the horizontal lines and project them up to the bevels, measuring along the top edge of the bevel gives half the width of face mould at the end the bevel is for.

Fig. 2. Is the face mould, the square A B C D, being drawn the same as Fig. 1. Having drawn the centre line, the next is to determine the horizontal trace or directing ordinate, for all ordinates must be parallel to this line.

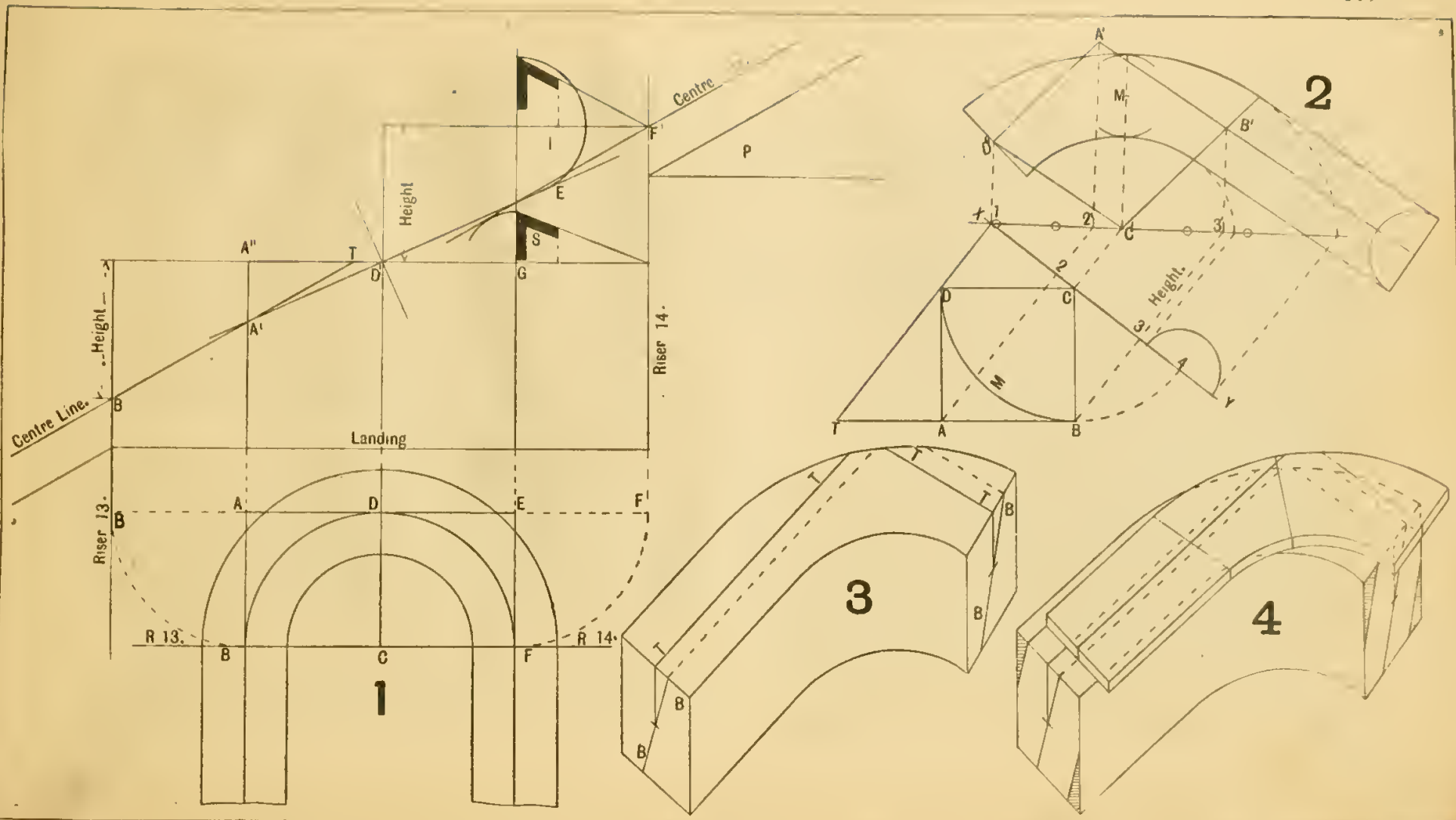
It will be seen that the centre line at Fig. 1 is drawn through the perpendicular A, A′, to meet the horizontal line at T, then A″ T, is the distance measured on A B produced at Fig. 2, that gives the point in the H T or directing ordinate, and D being in the horizontal plane is another point in the trace, then draw H T or ordinate, and draw X Y at right angles with it and through the centre C, then parallel with H T draw lines from A B C, on the line from B set up the height 3 3′ taken from Fig. 1, draw the line through 1. 3′, draw lines from 1, 2′, C′, 3′ at right angles to 1 3′, on these lines mark off the distances taken from the plan and measuring from X Y, 1 D′, 2′ A′ C′ M′ 3′ B′, join D′ A′, and make the joint at D′ square with this line, join A′ B′, and produce it to any convenient length, make the joint square with A′ B′, set off the width on each side taken from the bevel for the shank S at Fig. 1, draw lines from D′ to C′ and through B′ to C′, which is the springing line.

To draw the curves for the inside and outside of the rail, continue the centre line from B to 4 in X Y, then set off half the width of the rail on each side of 4, project these to meet 1 3 as shown by the dotted lines, these two points give the semi-major axis for both curves measured from C, C M is the minor axis, set off half the width of rail on each side of M, this gives the semi-minor axis for both curves. Draw the curves with a trammel or string and pins, which to be correct must pass through the points on the line C′ B′ and the tangent lines on the face mould B′ A′ and A′ D′ must be the same length as B′ A, A′ D′, in the development Fig. 1.

In practice, as soon as the line 1 3′ is drawn with all the points on it, the face mould is drawn on a thin piece of stuff with a gauge line run on at a convenient distance from the edge, this gauge line represents the line 1 3′, all the points on 1 3 are marked on the edge of the board and squared over on the face, and the distances marked from the gauge line and the face mould drawn same as Fig. 2, then cut it out to the lines and square over on the other side the tangent, spring, and minor axis lines.

Fig. 3. Shows the wreath cut out square through the plank, planed true and the mould applied, the tangent lines T T pricked off and the joints marked. The joints are made square to these lines, square over the lines on the ends, mark the centre of the stuff on these lines, then with the bevel for each end draw the lines B B through the centre of the stuff; square over these lines on the face on both sides as seen by the dotted lines on the top side.

Fig. 4. Shows the face mould in position with the tangent lines held to the corresponding line on the wreath, the etched part shows the amount to be taken off.


Centre
P
Height
Centre Line.
Height
Riser 14.
Landing
Riser 13.
R 13.
R 14.
1
2
3
4
Height.

HANDRAILING—*Continued.*

Fig. 1. Is the plan of a rail for a quarter space landing, the risers landing and starting being placed in the springing of the well. The radius of the centre line of rail being equal to half a tread, the pitch board gives the inclination of both tangents. If a square block be cut with two of its adjacent sides to the same pitch, it will be seen that a line joining the two opposite corners is horizontal, this being known, it is unnecessary to unfold the tangents.

Fig. 2. Draw a square A, B, C, D, same as the square A, B, C, D, at Fig. 1, draw one diagonal, which is the directing ordinate, draw the line X Y at right-angles with it, and draw lines from D and B parallel to the ordinate. Referring to Fig. 1, it will be seen that the rail in coming up from springing to springing will rise the height of one riser. Again at Fig. 2, on the line from D set up the height of one riser, draw the line from 1 through C′, a second line is drawn parallel with the first, this line would represent the gauge line on the stuff for the face mould, square over the lines on the stuff, from 1, C′ 3′, on these lines mark off the distances taken from the plan 1, B′ C M A, and 3 D, and through the points draw the tangent lines A B′, A′ D′, and B′ C′, C′ D′ the springing lines, produce the tangent lines any convenient length and make the joint lines square with them.

To draw the bevel, place the pitch board on the side A D of the square with its tread side to the line, and draw the pitch through A which is the inclination of the tangents, then with D as centre draw the circle tangent to the pitch and cutting the side C D produced, draw the line from the intersection to A, and in the angle is seen the bevel for both ends. Set off half the width of rail on D A, project it up to the bevel, this gives on the top edge half the width of face mould at each end, set off this width on each side of the tangent-lines A′ B′, A′ D′, and draw parallel lines through the points to the springing-lines C′ B′, C′ D′. To draw the curves turn the centre line round to meet X Y at O, on each side of O set off half the width of rail, project these on to the line 1 3′ which gives the semi-major axis for each curve. On each side of M on the minor axis line set off half the width of rail, these give the semi-minor axis for each curve, draw the curves which must pass through the points on the springing lines on each side of B′ and D′.

Fig. 3. Is the wreath worked into cylindrical form and the lines on ready for squaring. To draw the lines on the stuff, a thin piece is made to the size of the rail before being moulded, and a gauge line run through the centre both ways, the one through the depth is held to the line drawn across the end or joint with the bevel, and the other kept to the centre of the stuff, mark the top and bottom which gives the shaded portions to come off. The line through the centre is squared over on each side as far as the springing lines at S S, the minor axis line is drawn across the stuff parallel with the springing lines, mark the centre of the stuff on this line, and with o as a centre, and the compasses set to half the depth of the rail, draw the two arcs as shown. The outside of the wreath is marked in the same manner.

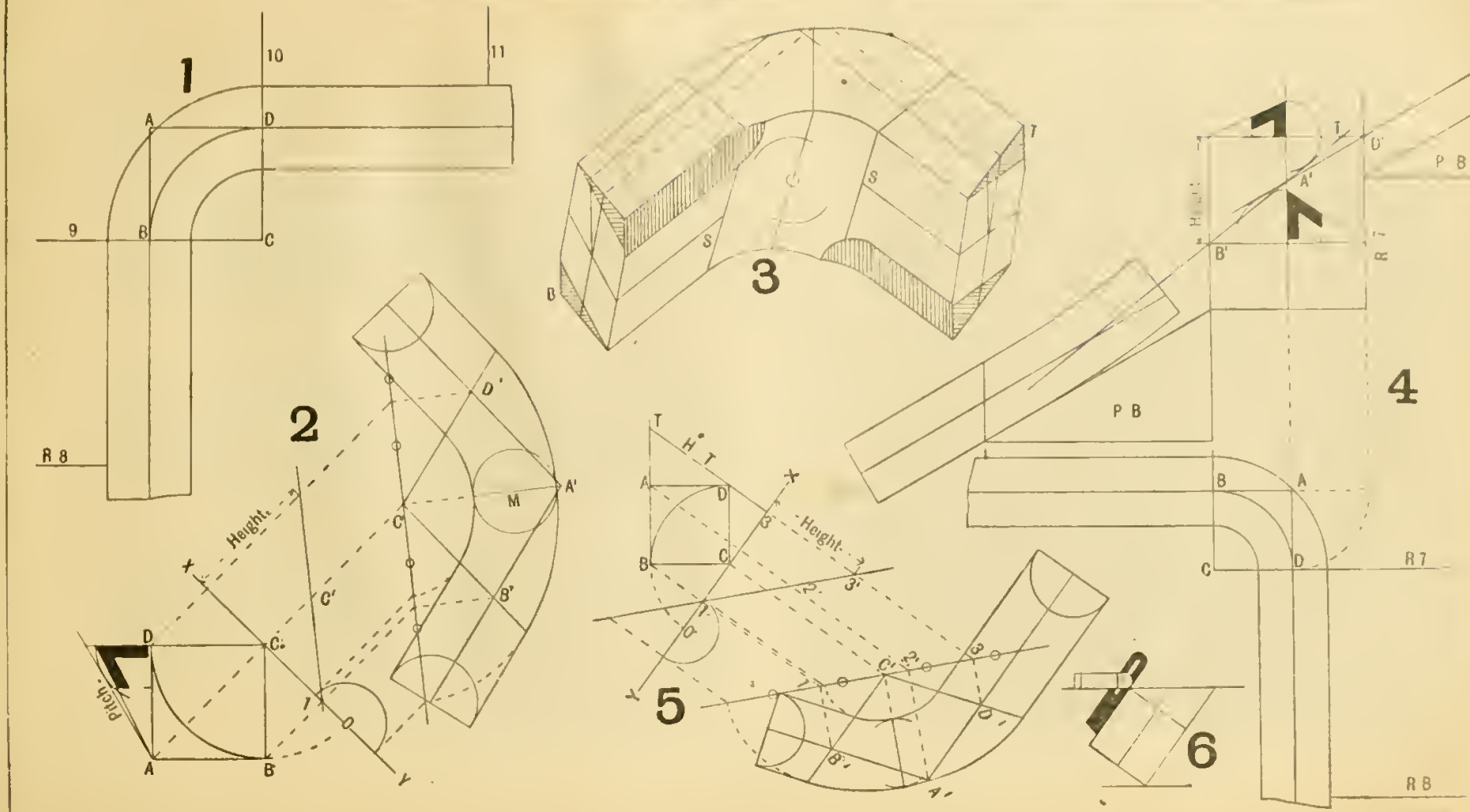
In squaring the wreath, the slabs at B and T are worked off square with the joint as far as the springing lines, then eased round tangent to the arcs of circles, the two opposite slabs being worked off parallel to the depth of the rail.

Before being squared the height must be tested, the wreath is put in the vice or bench screw, and the sides and springing lines set perpendicular to a board planed true and laid on the bench top. With one end of a rod on the board, mark the point where the centre line cuts the springing line at S, then move the rod round to the other point S still keeping the end on the board, and mark the point, if the distance between the two points on the rod equals the "height" at Fig. 2 the wreath can be squared, if not the centre lines must be raised or lowered to suit.

Fig. 4. Is the plan and stretchout of the tangents for another quarter space landing, the centre line being struck with a smaller radius than Fig. 1. The tangents are unfolded and the centre line drawn at the top and bottom portions as shown, the centre line A′ D′ is produced past A′ which is the point where the centre line of the lower portions must meet it, it will be seen that if the centre line of the lower portion had been produced, it would cut the perpendicular below A′, then the pitch must be altered, to lengthen as few balusters as possible, this must be done from about the centre of the last step as shown by the pitch-board, draw the line B′ A′ as shown. Bisect the angle, draw the joint-line to meet the bisecting-line, which is the centre the ramp is struck from.

Fig. 5. Shows the face mould for Fig. 4, obtained in the same way as those for Fig. 1 on the last page.

Fig. 6. Shows how the usual thickness allowed for the wreath is obtained, when there is a different bevel for each end, the one with the more acute angle is used.


1
10
11
A
D
9
B
C
R 8
2
Height
Pitch
D'
A'
M
C'
B'
X
Y
3
S
T
B
4
P B
R 7
R 8
5
H T
Height
6

HAND-RAILING—*continued.*

Fig. 1. Is the plan of centre line of rail for a well with six winders, as shown, two of them being in the springing at each side. Draw the tangent lines, the joint line C D, and the springing lines B C, C F, forming two squares as shown.

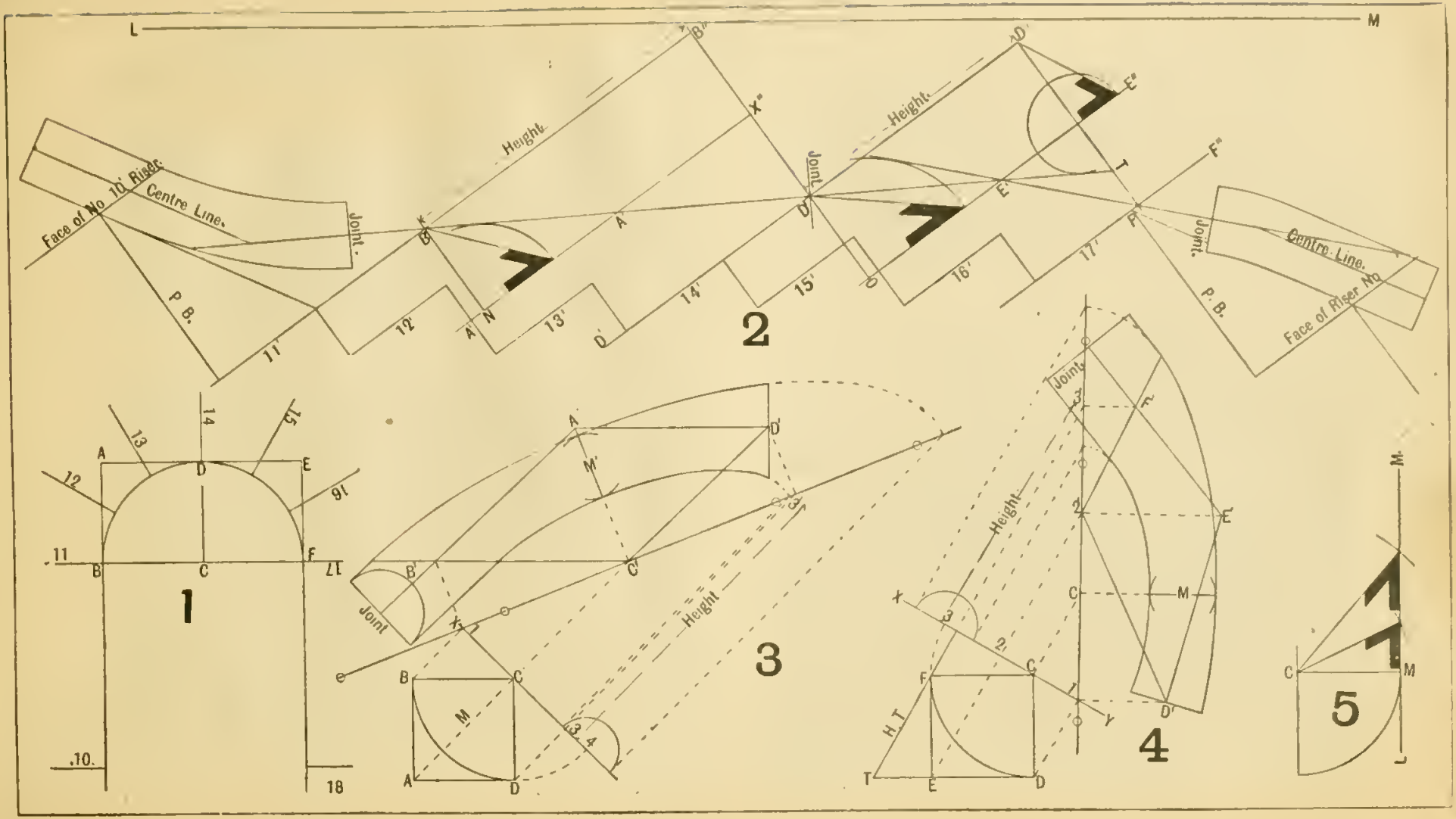
Fig. 2. Is the stretch out or development of the tangent lines. To draw this let the line L M be the edge of the drawing board, with a bevel set to a convenient angle, the end of the winder and riser would give the pitch, draw the line B′ B″, then parallel with B′ B″ draw A′ A″ at a distance equal to the side B A of the square at Fig. 1, and the same with D′ D″, E′ E″ and F′ F″. Place the pitch board with its riser side to the line B′ B″, as shown, and draw the last straight step, from the top of the riser draw the line at right-angles to B′ B″, for the first winder, this being the development of the tangents, the width of each winder is taken from where they cut the tangent lines at Fig. 1. Then on the first winder, from B′ B″ mark off the distance B to R 12, Fig. 1, and through the point draw R 12′, with the pitch board mark off the height of a riser, and through the point draw the line at right-angles to A′ X″ for the second winder, from A′ X″ mark off the distance A to R 13, Fig. 1, and through the point draw R 13′ the height of a riser, and draw the line at right-angles to D′ D″, for the third winder.

Referring to Fig. 1, it will be seen that riser 14 passes through the point D, then R 14′ is on the line D′ D″, mark the height of a riser, and draw the line at right-angles for the next winder, the drawing for the top winders up to R 17′, is just a repetition of what has been done for the others. Then from R 17′ draw the next straight step, and from the top edge of the pitch board top and bottom, set off half the depth of the rail and draw the centre line as shown, it will be seen that if the centre line at the top had been continued straight to meet E′ E″ the rail would be too high over winder 16, then the rail must be lowered at F′ but not more than half its depth. From the centre line at about the centre of the step, draw the pitch to E′ as shown; draw the pitch A′ E′ nearly parallel with the winders, in this case it is continued down to meet the centre line at the bottom, if this should make the rail too high at winder 13, then the pitch must be lowered at A′, and A′ B′ drawn to another pitch, where the pitches meet the centre lines at top and bottom, bisect the angles, and draw the joint lines square with the pitches, and to meet the bisecting lines which gives the centres the ramps are struck from, the joints should be kept clear off the springing lines B′ B″ and F′ F″. The ramps may be made any length, the centre lines must be marked on the templets and the face of the risers 10 and 12 as shown, and transferred to the ramps, the lengths of the straight rail can be got from these riser lines, and all can be jointed with accuracy.

Fig. 3. Is the face mould for the lower portion, the drawing being similar in every respect to what has already been described, the height is taken from where the pitch or raking tangent cuts the springing line B′ B″ Fig. 2, to the line drawn at right-angles to D′ D″ through the joint, the pitches being the same, the bevel answers for both ends, where the line from B′ cuts A′ A″ at N, with N as centre, draw the circle tangent to the pitch and cutting A′ A″, from the intersection draw the line to B′, and in the angle is seen the bevel. The straight portion of the face mould from B′ to joint Fig. 3 is made the same as B′ to joint at Fig. 2.

Fig. 4. Is the face mould for the top portion, to find the height where the pitch cuts the springing line F′ F″ Fig. 2, draw the line F′ F″ at right-angles to D″ then to the line drawn at right-angles to D′D″, through the joint is the height; where the line through the joint cuts E′ F′ at o, with o as centre draw a circle tangent to the pitch, and cutting the line E′ E″, from the intersection draw the line to D′ and in the angle is seen the bevel for the shank end; where the line F′ D″ cuts E′ E″ as centre draw a circle tangent to the lower pitch and cutting the line E′ E″, from the intersection draw the line to D″, and in the angle is seen the bevel for the centre joint, make F joint Fig. 4 same as F joint Fig. 2.

Fig. 5. Shows a simple method of finding the bevels, and one which answers in every case. Let L M, be the edge of the drawing board, square over the line C M, make C M equal to the radius of the centre line of rail. Then at Fig. 4, with C as a centre, draw an arc tangent to the line E′ D′, then with C′, Fig. 5, as a centre and the same radius, draw the arc cutting the edge of the board, as shown; draw from the intersection to C, and in the angle is the bevel for that end of the wreath. Again at Fig. 4 with C′ as a centre, draw an arc tangent to the line E′ F′, and repeat at Fig. 5 for the bevel for that end of the wreath. These bevels can be tested with those at Fig. 2, and they will be found to be exactly the same.


L
M
Face of No 10' Riser
Centre Line.
Joint.
P. B.
Height
Joint
Height
Joint.
Centre Line.
Face of Riser No
P. B.
11'
12'
13'
14'
15'
16'
17'
2
1
3
4
5
Joint
Height
Joint
Height
H.T.

HANDRAILING—*Continued.*

This chapter is devoted to a wreath at a quarter space landing, the risers, landing, and starting placed with no regard to the falling line of rail.

Fig. 1. Is the plan of the wreath showing the risers and tangents.

Fig. 2. Is the development, being a repetition of what has been done in previous chapters, it will be seen that the centre lines of the straight rails (if produced) would not meet on the perpendicular A′, then there are three ways this wreath may be worked out by the tangent system. First, with the wreath in one piece and to form its own easings,* to do this settle on the position of the joints J J, (the shorter the shank ends the less thickness will be required for the wreath), from J J draw the pitch across the well, the point where this line cuts the perpendiculars B′ and D′ gives the height.

Fig. 3 The pitches of the wreath being equal, the face mould is drawn same as those in previous plates.

Fig. 4. Is an Isometrical sketch of the wreath worked into cylindrical form. Cut out the wreath a little wider than the face mould, square through the plank, plane one face true and apply the face mould, marking the joints and transferring the tangent lines to the stuff, those are represented by the dotted lines. At first the joints are made square to those lines and to the face of the wreath, square the lines over the ends as far as the centre C, then with the bevel shown at Fig. 2 draw lines across the ends through C, from those lines draw lines square from the end on each face of the wreath, the tangent lines on the face mould are held to these when marking and working the wreath into cylindrical form. When the face mould is in its position on the wreath (when worked), draw lines across each side of the wreath from the springing and minor axis lines as shown, draw the line through C square with the line drawn with the bevel, from this line draw square from the end the centre line J S on the side of the wreath. Referring again to Fig. 2, it will be seen the centre line of the straight rail meets the perpendicular springing line D′ at T, then make a thin piece of stuff to the exact shape of the triangle J S T, apply this to the wreath at Fig. 4, with the side J S to J S, and S T to the springing line, draw the line J T, which is the new centre line, the joint is then made square to this line and the side of the wreath, this will be repeated at the other end. Then test the height and square the wreath, the shank ends must be worked off as far as necessary parallel to the new centre line J T. Should it be necessary to have the shank ends the exact length shown at Fig. 2, the tangent lines on the face mould, B′ J and D′ J, Fig. 3, would be made to T J instead of S J Fig. 2, to allow T J on the wreath Fig. 4 to be the same length as T J Fig. 2, this would be immaterial in joining up to straight rails, as the springing lines are drawn across the underside of the wreath and the lengths are taken from them. For the extra thickness required for this wreath the distance S T Fig. 2 would be quite sufficient over what is usually allowed.

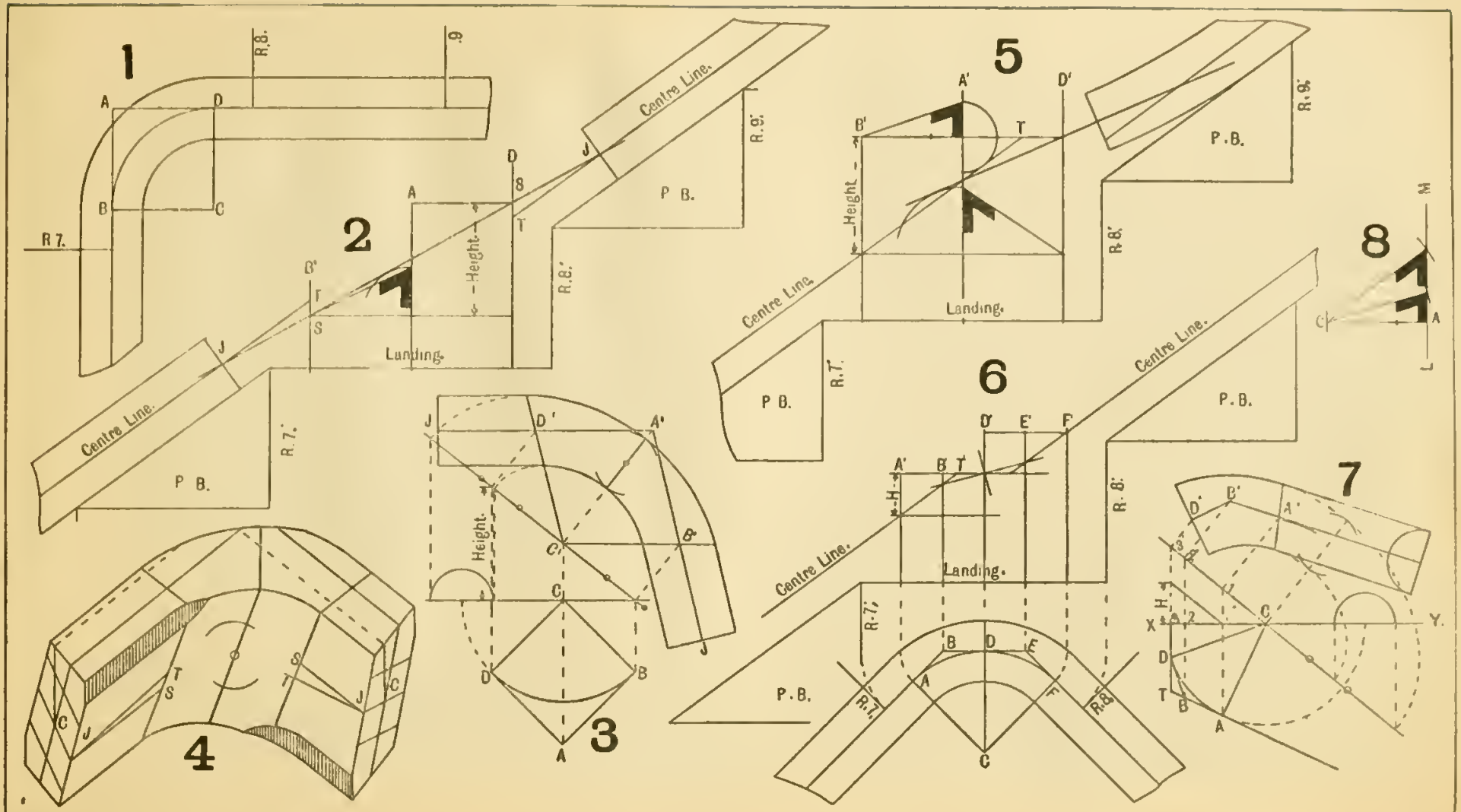
Fig. 5. Is the development for the wreath to be in one piece with the easing on the straight rail at the top, the face mould is not drawn, being similar to those already explained.

Fig. 6. Is the development for the wreath to be in two pieces, re-draw the plan same as Fig. 1, draw the joint line C D, and draw B E tangent to the centre line and at right angles to C D. Produce the centre lines past A and F to meet B and E, with B and E as centres turn the springing and riser lines round, project them up parallel with C D, draw the landing line at right angles to C D, place the pitch board at R 7, draw the pitch and centre line, at R 8 set up one riser above the landing, then draw the pitch and centre line. From where the centre lines cut the perpendiculars B′ and E′, draw the pitch in the centre of the wreath, and where this cuts the perpendicular D′ gives one point in the height, and the joint is drawn through the intersection, and where the centre lines cut the perpendiculars A′ and F′ gives the other points in the heights, as shown by the horizontal lines.

Fig. 7. Is the face mould, re-draw the centre line with its tangents A B and B D, produce A B to T, making B T same as B′ T, Fig. 6, draw the ordinate T D, draw X Y at right angles to T D through the centre C, draw projections from A and B, and on T D produced, set up the height H taken from Fig. 6, from where the projector from A cuts X Y draw the pitch of plank, parallel with this draw the line through C, where the lines from T D, B, and A cut this line draw lines at right angles. Measure on these the distances 1 A, 2 B, and 3 D, join A′ B′ D′, make the joint square with B′ D′, draw the springing line through A′ to C, on the line from C set off the radii of the inside and outside of the rail for the minor axis, turn the centre line round to meet X Y at O, set off half the width of rail on each side, project these down to meet the pitch line for the major axis, and draw the curves.

Fig. 8. Shows the bevels, let L M be the edge of a board, square over a line, measure off on this the radius of the centre line of rail C A, then with C, Fig. 7, as centre, draw an arc tangent to A′ B′, then from C draw the arc cutting L M, draw from the intersection to C, and in the angle is the bevel for the shank end, set off half the width of rail on A C, project this up to the top edge of the bevel, take the distance along the top edge of the bevel and set it off on each side of the tangent A′ B′, Fig. 7, draw the lines parallel with A′ B to meet the springing line, the elliptic curves must pass through these points. The shank end can be made any length, for the bevel at the other end, the arc must be drawn tangent to B′ D′, Fig. 7, and repeated as shown.

* *This involves the principle laid down by* R. Riddel *in his answer to a Western builder, and is one that has been discussed at great length.*


1
2
3
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7
8
Centre Line.
Height.
Landing.
P. B.
R.7.
R.8.
R.9.
R.7'
R.8'
R.9'
A
B
C
D
E
F
J
S
T
A'
B'
C'
D'
E'
F'
H
X
Y.
M
L

HANDRAILING—*Continued.*

In the system of handrailing known as the section of e cylinder through three given points, or the face mould plane through three points, the section is determined through an imaginary solid containing on its surface the centre ine of rail, and its base being defined by the plan of the centre line.

Fig. 1. Is the plan and development of the centre line of a rail for a well with two quarter space landings, the risers being placed in the springing at each side of the well. To draw the development of the centre line, draw the equilateral triangle on the diameter of the centre line, produce the two sides to cut the line drawn tangent to the centre line and parallel with the diameter, between the intersections is the stretch-out or development, and the perpendicular lines S S are the springing lines. Place the pitch board with its riser side to the line S at R 7′, draw the line along the top edge where it cuts the springing line, draw the first-landing at right-angles to the springing line. On the line projected from the centre of the well mark off the height of a riser and draw the second landing, on the springing line mark off the height of a riser and draw the horizontal line, place the pitch board with its tread side to this line and the point to the springing line, and draw the line along the top edge for the underside of rail, from the top edge of the pitch board at top and bottom portions set off half the depth of rail, and draw the centre line to meet the springing lines at S′ S′, join S′ S′ and draw the easings between the two lines at top and bottom, and where the line S′ S′ cuts the perpendicular from the centre of the well draw the joint line through the intersection, also the horizontal line to the left. Draw the joint line at the shank of the lower portion at right-angles to the centre line, from the centre of the rail erect the perpendicular 1′ 3′ to meet the horizontal line through the centre joint, 1′ 3′ is the height the bottom portion of the wreath rises, and also the height of two of the points the section plane must pass through. The middle resting point may be taken in the centre of the development for that portion, if the shank is short, as in this case, but when the shank is long the middle resting point must be taken in the curve, about one-third the distance between the springing line and centre joint, in this case the horizontal line through the centre joint and 3′ is divided in two, and the perpendicular dropped, to meet the easing line from the intersection draw the horizontal line to meet the perpendicular at 2, which gives the height of the middle resting point the plane must pass through.

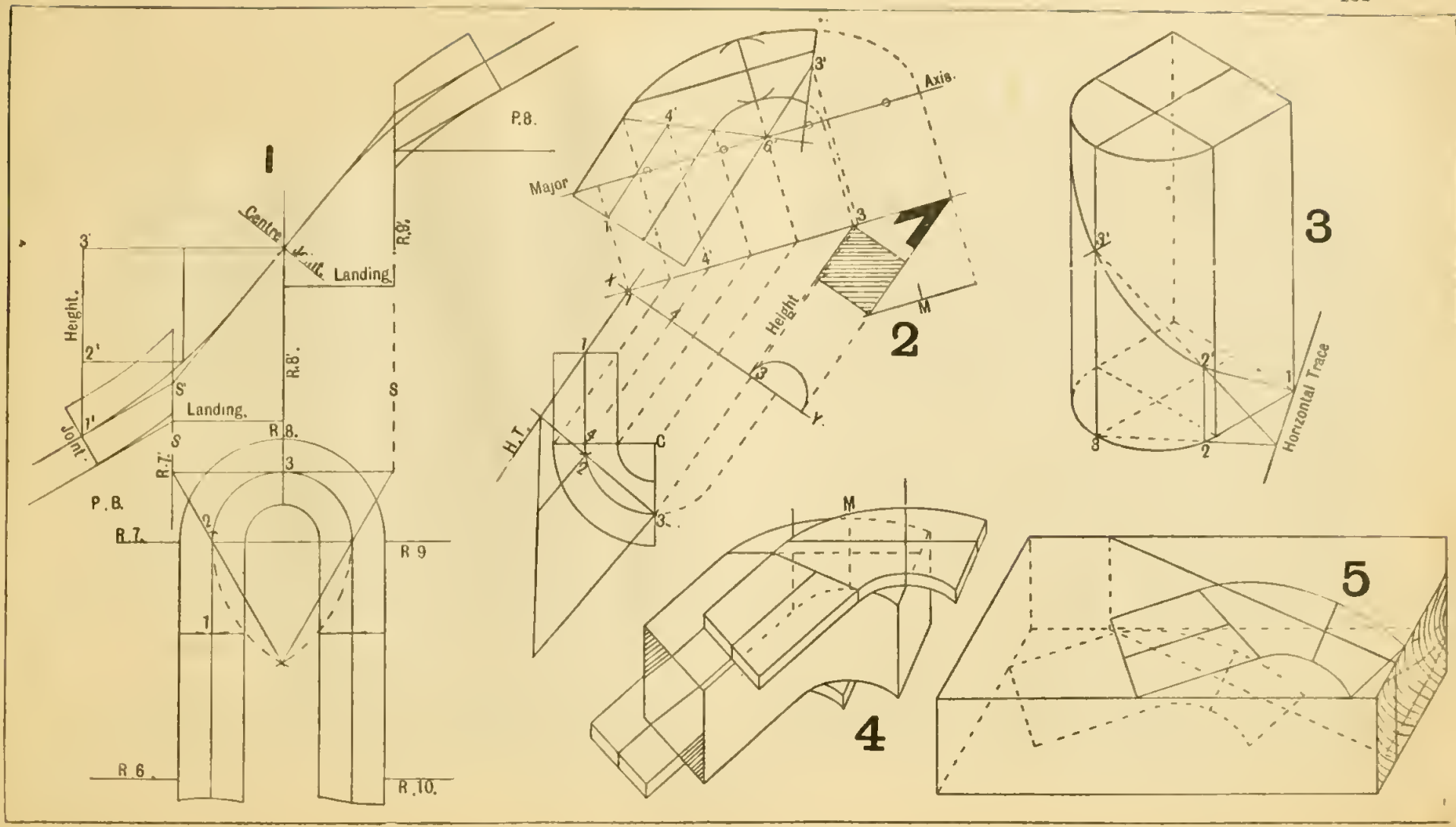
To draw the section these points must be determined in plan. From 1′ in the centre of the shank joint draw the horizontal line to the springing line, take this distance in the compasses and mark the centre line in the plan from springing to the joint at 1; take the distance from the springing line to the middle point at the easing, and mark the distance from the springing to 2 in the plan, then 3 at the centre joint in plan gives the third point.

Fig. 2. Re-draw the plan with the points as shown, join 3, 2, and produce the line to the left, on this line erect perpendiculars from 3 and 2, make the one from 3 the height of 1′ 3′ at Fig. 1, and the one from 2 the height of 1′ 2′, Fig. 1, draw a line through the points meeting the line joining 2 3, which is one point in the horizontal trace, the point 1 at the centre of the shank joint is in the horizontal plane. Draw H T through these points; draw x y at right angles to H T, draw ordinates from the centre and each side of the rail at the springing line; across the rail through C and from 3, at the centre joint on the line from 3, set up the height 1′ 3′ Fig. 1, above X Y, draw the lines 1 3′ which is the pitch line. From where the ordinates cut this line, draw lines at right-angles, measure off on these lines from the pitch line, the corresponding points in plan, measured from X Y, the curves may be drawn with the trammel, turn the centre line round and draw the line tangent to it parallel with the ordinates, set off half the width of rail on each side of this line, project these up to 1 3′, and to the major axis line, which gives the semi-major axis for both curves, the semi-minor being on the line through C, draw the springing line 4′ C′, and draw the line through 3′ C′. The joints are made at right angles to these produced at 1′ and 3′ as shown, draw the shaded section, and the line through the bottom corner shows the thickness for the square rail. In the angle is seen the bevel to slide the mould by, the dotted line from the top point of the bevel cutting the line through the bottom corner of the section gives the whole distance the mould has to slide, bisect this line at M, draw the line on the face mould through the centre of the rail on the minor axis line parallel to the major axis and pitch line, apply the face mould to the plank, and cut the piece square through a little wider than the face mould. Plane one face true and transfer the minor axis line and the line parallel with the major axis from the mould to the stuff, square over the minor axis line on both edges, mark the distance from M to the dotted line at Fig. 2, on one side of the minor axis line at the top, and on the other at the bottom.

Fig. 3. Shows an Isometric projection of the cylinder with the lines on the surface.

Fig. 4. Shows the face mould in its position when held to the tangent lines; this is known as the square cut.

Fig. 5. Shows the mould marked on the top and bottom faces of the plank, the mould being moved along the line on the underside to the distance given at Fig. 2. The wreath is cut out to those lines; this is known as the bevel cut, the top portion of the wreath is the same as the bottom; To make the joint at the shank end it may be necessary to use the short piece of falling mould, as at Fig. 1.


1
P.8.
Centre
Landing
R.9.
Height.
Landing.
Joint.
R.8.
R.7.
P.B.
R.7.
R 9
R 6.
R.10.
2
Major
Axis.
Height
H.T.
M
3
Horizontal Trace
4
5

CARPENTRY AND JOINERY.

On the opposite page are the Drawings for the Model I submitted to the Examiner in Carpentry and Joinery in 1886. Also a copy of the Voucher and particulars which were forwarded with the Model.

Carpentry and Joinery-Honours Stage.

The model is intended to be used in classes in carpentry and joinery; it is to show a few different methods of finishing roofs, but principally the necessary bevels.

I have introduced as many varieties as the size, &c., would allow. It is not made to any proportionate scale, as parts have been exaggerated to show more clearly such parts as the purlins, hips, and stays. The triangular louvre frame and the square turret are good examples in projection and developing. The louvre boards are not all shown, as they are understood from the one given. The spandrails when small may be covered with lead, or if large may be filled in with louvre boards, one of which is shown in the side B, or they may be slated.

The bevel for the sill to the square turret is the same as the backing for a hip. The roof to this is not shown, as the bevels for it may be found in the same way as those for the main roof.

Both the square and triangular frames may be removed by taking out the screws.

Plan, elevation, section, and a few of the more important bevels are shown.

The work is entirely my own without any assistance whatever. John Wilson, joiner, teacher of building construction, geometry, carpentry and joinery, in the Technical School, Manchester.

For those who wish to follow the bevels, &c., the following brief particulars will be useful:—

Fig. 1. Shows a front elevation and section of the triangular ventilator. A is the front elevation, with one side developed, showing the cut for the bottom to fit the sill, and the trench to receive the end of louvre board. S shows the side cut to louvre board, and L shows the bevel for the trench in the sill. B shows a vertical section through the frame, &c., C shows the pieces developed, these are nailed on the spars to receive the ends of the boards that form the spandrails.

Fig. 2. A shows the backing for the hip, a small piece being planted on, in practice this is solid, but was planted on to allow the hips to be left square on the top side. This shows the peculiar finish to hips when left square. See front and end elevation. (Also part elevation, Fig. 6) B shows a section through a spar and board. C shows the side cut for the same. D shows the thickness of the board exaggerated, and E shows the edge bevel to mitre the boards. Note.—The boards are mitred on one hip and lapped on the other. These are only put on to show the bevels.

Fig. 3. Shows a jack rafter or spar, and part plan of a hip. A shows the bevel for the plumb cut to spar, and B shows the side cut to the same.

Fig. 4. Shows a front and side view of strut to purlin, section and part of side elevation are shown, and the top side of the strut is developed to show the necessary cut to fit the angle of the purlin.

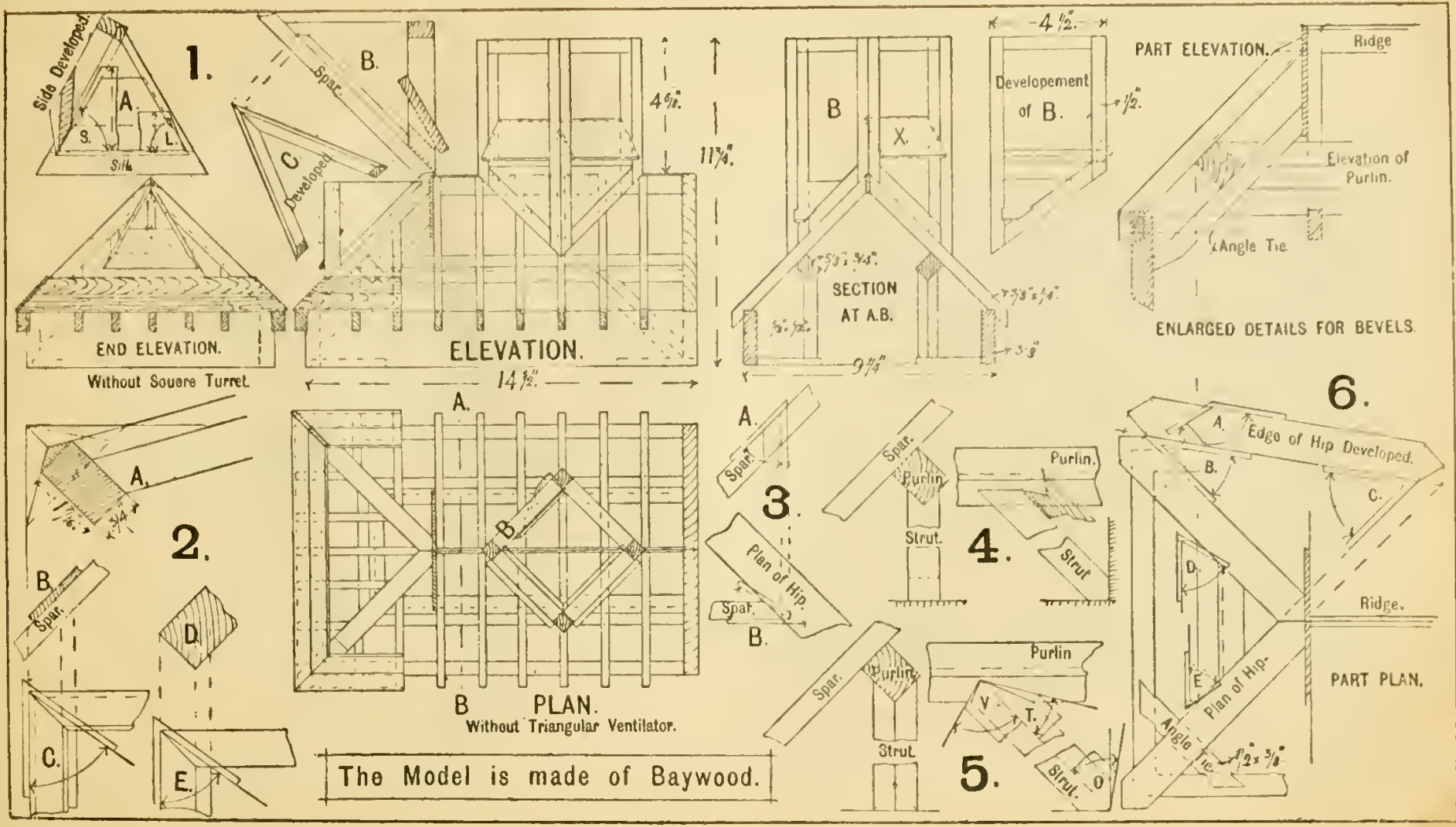
Fig. 5. Shows the bevels to the strut when placed diagonally. V shows the bevel for the underside, and T the one for the top side. O shows the bevel for the bottom. Note: both sides are the same. To show where the strut dies out on the purlin, take projectors from the front view.

Fig. 6. This is drawn to a large scale to show the bevels to the purlin, &c. Part plan shows hips, purlin and angle tie. Note: one hip runs into the angle. The edge of this is developed to show the bevels. A shows the bevel required to cut the hip to fit the angle, the bottom end and the mitering for the top are to the same bevel. B shows the horizontal cut for the foot, and C shows the plumb cut.

D shows the side cut to purlin, and E shows the edge cut for the same.

A few of the principal sizes are figured on the drawings.

To those who are not very good at projection this will furnish some good examples in addition to those named. The projection of one of the louvre boards as X seen in section, and afterwards the one that is shown in side B should be tried. These should be to a large scale, plan, elevation, and section should be drawn.



The Model is made of Baywood.

BUILDING CONSTRUCTION.

Instead of giving all the text for the plate, the first and last are given, and also a few examples and exercises from various parts, believing that you will by this method be able to form a better opinion of the nature and scope of the work.

From page 96.

BRICK, SEWER, AND STONE STAIRS.

Fig. 1. Shows a section of the ovoid or what is generally known as the egg-shaped sewer. The size and shape of these vary, but the example is an ordinary specimen, the internal height and width being as 3 : 2. The centres from which the different curves are drawn being shown by small circles. This class of sewers is used for carrying off the rain-water from the street, &c., &c. In preparing for these the trench is first dug out to the necessary width and depth (except where they are very deep, and then they are tunnelled.) If the soil be loose it is prevented from falling in by boards put in against the sides. These are prevented from being pushed in by cross pieces, sometimes planks, 9″ × 3″ are placed against the boards. These planks are parallel with the surface, and the cross stays are cut in between them.

The vertical pieces are poling boards, and the planks referred to are known as the wailing pieces.

The principal part in a sewer is the bottom or lower half, as the scour and tendency to leak is greatest near the bottom. In general a terra-cotta block makes the best, the one shown being rebated, as this prevents a straight joint between the brickwork and block. The lower half is built of specially made bricks, which should be hard, smooth, and well burnt, and laid in good hydraulic mortar; neatly pointed at the joints, and left as smooth and even as possible.

The upper half may be built of common bricks, only a few of which have been filled in.

Fig. 8. Shows two steps, and iron balusters for the same. The steps are spandrail, or feather-edged for hanging stairs, that is when they are built into the wall at one end. This reduces the weight. When there is a limited space for head room it is an advantage, and stones with the corners off may be used when they would not pass for the square-edged steps shown at Fig. 4.

One of the steps, &c., is shown in section, the bottom of the balusters is prepared for fixing in the stone with lead.

Part plan of one end of a step is shown. A small part marked a at the side of each baluster in plan is shown, that is, where the lead would be poured in.

The arrangement, &c., will be understood by a perusal of the drawings

From page 133.

Fig. 2. Let the weight be placed at C, 4′ from A, the reaction at $A = \frac{W \times BC}{AB} = \frac{10 \times 16}{20} = 8$ tons. Reaction at $B = \frac{W \times AC}{AB} = \frac{10 \times 4}{20} = 2$ tons

It will be seen that the sum of the two, equals the original weight, 10 tons. These must always equal the original weight; further, the reaction at A (Fig. 2) × A C = reaction at B × B C.

From page 127.

Exercise 9. Cast iron will resist say 42 tons per square inch in compression. Determine the resistance of a short hollow circular iron column, the diameters being 6″ and 5¼″ respectively.

Area external circle $= 6^2 \times \cdot 7854 = 36 \times \cdot 7854 = 28 \cdot 2744$ sq. ins. Area internal circle $(5\frac{1}{4})^2 \times \cdot 7854 = (\frac{21}{4})^2 \times \cdot 7854 = 21 \cdot 6476$ sq. ins. Sectional area or the difference $= 28 \cdot 2744 - 21 \cdot 6476 = 6 \cdot 6268$ sq. ins. Resistance $= 6 \cdot 6268 \times 42 = 278 \cdot 3256$ tons.

From page 128.

Exercise 18. A square building 20′ side, is to be covered with a hipped roof, the sides are all equally inclined at 27½°, and meet in a point. Determine the length of a hip.

First find the distance from the eaves to the apex (see table) $= 10 \times 1 \cdot 1274 = 11 \cdot 274$ ft. Length of hip equals the hypothenuse of a right angled triangle, sides 10 ft. and 11·274 ft. Length of hip $= \sqrt{(10^2 + 11 \cdot 274^2)} = \sqrt{(100 + 127 \cdot 103)} = \sqrt{227 \cdot 103} = 15 \cdot 07$ ft.

From page 130.

Exercise 14. Determine the section of a cast-iron girder to carry a safe distributed load of nine tons over a 20 feet span.

Assume the depth of girder to be 12″, or $\frac{1}{20}$ the span; then (stress in flanges) $\times \frac{12}{12} = \frac{9 \times 2240}{4} \times \frac{20'}{2}$; stress = 50400 lbs. Factor of safety = 3.

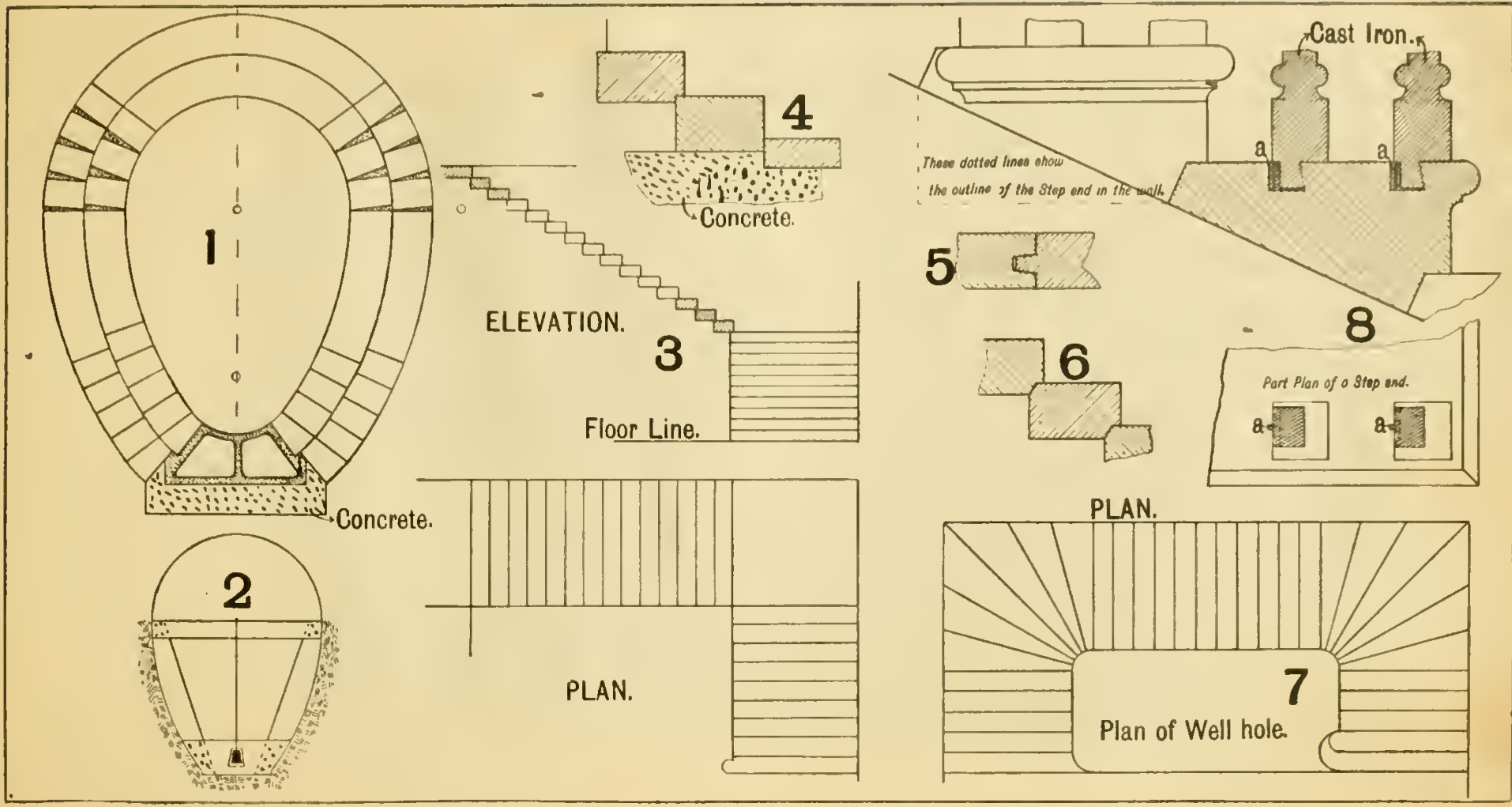
Area of bottom flange $= \frac{50400 \times 3}{16500} = 9 \cdot 16$ sq. ins.

Area of top ,, $= \frac{50400 \times 3}{112000} = 1 \cdot 36$ sq. ins.

To find the dimensions of the flanges when the proportions are given.

Say bottom 6 : 1. $6 \times 1 = 6$; $\frac{9 \cdot 16}{6} = 1 \cdot 627$; $\sqrt{1 \cdot 527} = 1 \cdot 236$.

Dimensions of bottom flange are $1 \cdot 236 \times 6 = 7 \cdot 415$ and 1·236.
In practice the bottom flange would be 7⅜″ × 1¼″. Top flange, 1⅛″ × 1″.


1
Concrete.
2
4
Concrete.
ELEVATION.
3
Floor Line.
PLAN.
Cast Iron.
a
a
These dotted lines show
the outline of the Step end in the wall.
5
6
8
Part Plan of a Step end.
a
a
PLAN.
7
Plan of Well hole.

CONTENTS.—FIRST SECTION.

PAGES.		
8, 9	Scales, and the explanation of such as $\frac{1}{12}$, $\frac{1}{48}$, $\frac{1}{60}$, $\frac{3}{2}$, $\frac{5}{3}$, $\frac{8}{3}$, &c. Also, how to divide a given line into any number of equal parts	
10, 11	Brickwork.	Elevations of English, Flemish, Stretching and Heading-bond; with plans of two courses, ½, 1, 2, 2½, and 3-brick thick
12, 13	„	Dwarf-walls, showing brick and stone caps in section; also slate or tile creasings
14, 15	„	Intersection of main and partition walls, and reveals for door and window openings, showing king closer
16, 17	„	„ „ walls at right angles; showing differently arranged closers.
18, 19	„	Door and Window Openings, Arches, straight, and a relieving arch over a wooden lintel; and the use of wooden pallets
20, 21	„	„ „ Segment and other heads, and how to determine length of radius. Offsets, oversailing, corbeling, &c.
22, 23	Stonework.	Sills; Ashlar; rubble work, coursed and uncoursed; and orked up to courses with brick-lining.
24, 25	„	and Ironwork: Gable ends and joints with metal fastenings; cast and wrought-iron beams, and cantilever
26, 27	Leadwork.	Box and vee gutters, drips, rolls, and cesspool; stepflashing to chimneys, &c.; also a secret gutter.
28, 29	Slating.	Duchess and Countess: Sizes, gauge, lap, &c., with proper distance of nail-holes from the tail.
30, 31	Woodwork.	Single floor, with fireplace: Tusk tenon, herring-bone bridging and pugging.
32, 33	„	Double and framed floors, with joints; also joints for floor boards, both heading and cross joints.
34, 35	„	Partitions, showing how to truss them so that all the weight may be thrown on the wall; enlarged joints.
36, 37	„	Roofs: Couple, collar, and king, with details; also the method of drawing to ⅓ and ¼ pitch, when the span is given.
38, 39	„	Queenpost truss; with enlarged details showing heel strap, &c., &c.
40, 41	„	Iron roof-trusses, and details for the same.
42, 43	„	Doors: Ledged, ledged and braced; hingeing to either wood or stone.
44, 45	„	„ Ledged, braced and framed; showing joints, haunches, &c., to an enlarged scale.
46, 47	„	„ A four-panelled door, and large details for the same.
48, 49	„	„ A double-margin door, with details for a wall battened and plastered on one side.
50, 51	„	Sashes and frame, with enlarged details through the sill, meeting rails, head, and one side, and how to fix the same.
52, 53	„	Fanlight and casements, to open one way; also one hinged on centres, showing how to bevel the head, and cut the beads.
54, 55	„	Yorkshire light, French casement, jointing sashbars; keyed joints in circular work.
56, 57	„	Scarfed and built-up beams; Halving, lapping, fishing; scarfes for tension and compression.
58, 59	„	Joints in roofs, both bad and good. Mitred joints, for W.Cs., &c.
60 to 79	Have been compiled from previous examination papers.	
80	Syllabus.	

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96, 97 Common or flat arch, relieving arch, and Gothic arches.

98, 99 Brick and stone. Bond over opening and finishing to stone heads.

100, 101 Brickwork with stone dressings, showing different heights.

102, 103 Brick sewer; and stone stairs, showing balusters let into the step.

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106, 107 Wooden stairs and the principal of isometric projection.

108, 109 Centres for a segment, semi-circle, and a circular arch.

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114, 115 Skylights, both wood and iron.

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118, 119 Box and shutters for windows, with enlarged details.

120, 121 Rivets. Riveting, single, double, &c. Plate, box, and built up girders.

122, 123 Iron columns and girders, with details showing how to secure them together.

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130, 131 Cutting up timber.

132 to 136 Notes on timber.

137 to 162 Practical Arithmetic and Graphic Statics.

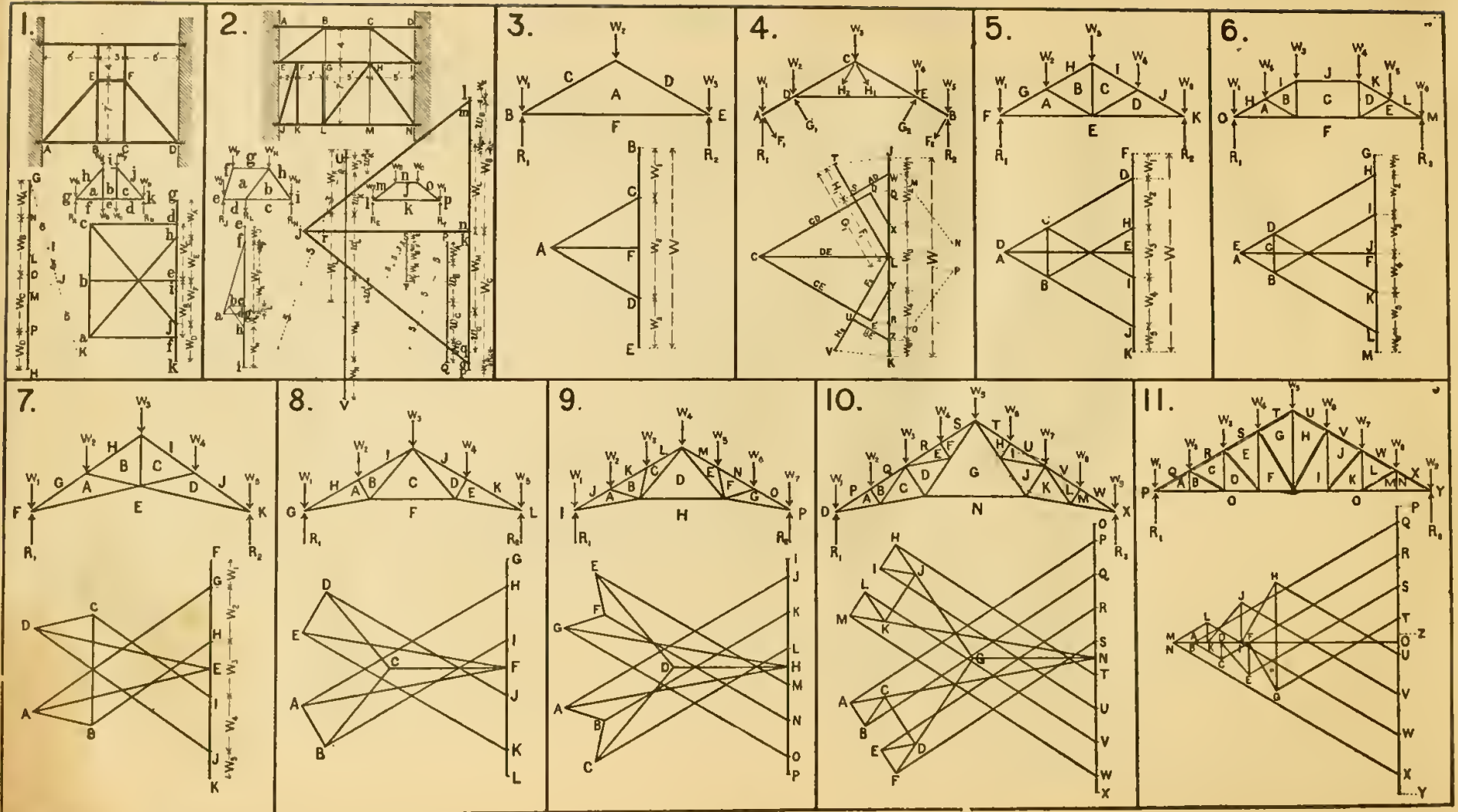
163 to 172 Exercises for the students.

173 Questions set for the Elementary stage, May 5th, 1883.

174 Answers to „ „ „ „

175 Questions set for the Advanced „ „

176 Answers to „ „ „ „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11.

CARPENTRY AND JOINERY.

The following is an abridged list from several hundreds received during the last few months.

"Your book supplies a long felt want, namely, a work containing a good technical instruction at a price which shall come within the reach of all who are desirous of such information."—*Joiner, Warwickshire.*

"Allow me to congratulate you for the neat and instructive way in which you have got your 'Carpentry and Joinery' and 'Building Construction' up. They are the best books that I have seen at anything near the price."—*Science Teacher, Yorkshire.*

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Note: Advanced Building Construction will shortly be revised.

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